APPENDIX A

Geotechnical / Hydrogeological Properties
Table A.1 Geotechnical / Hydrogeological Properties

<table>
<thead>
<tr>
<th>Catchment ID</th>
<th>Catchment Area (ha)</th>
<th>Fraction of Groundwater to Deep Aquifer</th>
<th>Proposed Infiltration Rates Distributed (mm/hr)</th>
<th>Proposed Infiltration Rates End-of-Pipe (mm/hr)</th>
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<tr>
<td>119</td>
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APPENDIX B

Hydrologic Modeling Update and Post-Development Analysis
Regional Storm Control Scenarios, Stantec letter dated September 30, 2008
Existing and Proposed Modeling Schematic
GAWSER Files (on CD, upon request)
B.1 Model Set-up

B.1.1 INTRODUCTION & BACKGROUND

A major component of the Blair, Bechtel, and Bauman Creeks Subwatershed Plan (the BBB Study) (1997) involved the completion of the original Blair Creek hydrologic model using the Guelph All-Weather Sequential Events Runoff (GAWSER) modeling software (Version 6X). This modeling, completed by Schroeter & Associates Ltd., represented the Blair Creek watershed hydrologically using 42 subcatchments, 18 channels, and 3 reservoir elements. The existing conditions model was calibrated and validated using observed streamflow data from four subwatershed locations for the period between April-December 1994. Six different post-development scenarios were also completed to test the hydrogeologic and hydrologic response of the BBB watersheds to potential urban development and resource extraction. The results of this modeling provided an important tool in the development of a subwatershed management plan.

Over the ensuing years, the GAWSER modeling software was revised and improved numerous times, with many of the additional capabilities directly related to the hydrologic characteristics of the Blair Creek watershed. By 2001, changes to the underlying software were significant enough that there was a desire to achieve confirmation that the original model remained valid for use as a planning tool. Schroeter & Associates updated the existing conditions model, including recalibration and revalidation with observed data, and again analyzed several potential development scenarios. The results of this work were summarized in the Blair Creek Watershed Hydrology Model: Revisions – Draft Summary Report (2001).

Within the current Study, the model was revised once again, this time by Stantec Consulting Ltd., in order to:

- Determine impacts related to the newest GAWSER release (Version 6.9.7)
- Reflect more detailed topographical and hydrogeological information
- Incorporate revisions to subcatchment delineation more appropriate for the anticipated development strategy, with consideration paid to property ownership information. While not necessarily relevant from a hydrologic perspective, property ownership was included as a parameter of consideration in subcatchment definition given the desire to have a model that is straightforward to continually update throughout the development process

The 2008 model revisions pertain only to those portions of the previous model on the Blair Creek system within the subject Study Area, i.e. the Upper Blair Creek watershed.

Dr. Harold Schroeter, the author of both the GAWSER software package and the previous Blair Creek hydrology work, was sub-consulted in an advisory and review capacity throughout the 2008 modeling work.
B.1.2 OVERVIEW OF MODELING PROCEDURES

The validated nature of the 2001 model provides a level of confidence in the underlying methodology. With this in mind, the methodology followed during the current modeling mimicked that of the 2001 version wherever possible. Comparisons of modeled results between the 2001 and 2008 models were completed over several temporal and spatial scales, and validation through comparison with observed runoff events was again completed. The steps taken to revise the Blair Creek watershed model are outlined throughout the following sections, with additional discussion included whenever the methodology differs from the previous work.

Modeling revisions were generally made with reference to the GAWSER Training Guide and Reference Manual (Schroeter & Associates, 1996), with more current information on GAWSER and its newer functions obtained directly from Schroeter & Associates.

B.1.3 SUBCATCHMENT DELINEATION

Both the 1994 and 2001 models followed the typical approach of delineating drainage areas based solely on topography and discharge points, with a total of 20 subcatchments representing the Upper Blair Creek headwaters area. Of those 20 subcatchments, 6 represent the Roseville Swamp area located south of New Dundee Road. Figures 4-2 and 4-3, along with Table 4.2, of the BBB Study are reproduced herein for reference.

The 2008 modeling revisions included additional discretization of subcatchments within the current work recognizing improvements in soils, hydrogeological, and topographical information, combined with the consideration of property ownership, as described previously. The total subcatchment count within the Study Area was increased to 38, of which 31 are used to represent the current Study Area. Table B1 outlines the relationships between the 2001 and 2008 subcatchment ID’s and their relative discharge locations.

There were slight changes in the overall drainage area between the 2001 and 2008 models, resulting primarily from the more detailed topographic information available for the 2008 model, allowing for an improved delineation of drainage area at the subwatershed perimeter.

Subcatchments within the Township of North Dumfries (generally south of New Dundee Road) and in the City of Cambridge (west of Highway 401) were left unchanged, as they are not within the Study Area. Table B1 illustrates the changes in the drainage area at various points along the Blair Creek system.
Table B.1: 
Relationship Between 2001 and 2008 Subcatchments

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<th>Discharge Location to Creek</th>
<th>2001 Model</th>
<th>2008 Model</th>
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<td>Subcatchment</td>
<td>Area (ha)</td>
<td>Subcatchment</td>
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<td>101</td>
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</tr>
<tr>
<td>106</td>
<td>38.9</td>
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<tr>
<td>Total to Reidel Drive</td>
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<td>210.5 ha</td>
</tr>
<tr>
<td>105</td>
<td>64.0</td>
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<td>88.0</td>
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<td>Total to New Dundee Road</td>
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<td>Total out of Roseville Swamp</td>
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<td>Total at Hwy 401</td>
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<td>1100.0 ha</td>
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</table>
B.1.4 SOIL AND LAND COVER

The subcatchment areas were divided into nine Hydrologic Response Units (HRUs) that GAWSER employs to assign various soil and infiltration properties. An HRU is a combination of soil and vegetation type such as impervious area with no vegetation, or a low infiltration soil with forest cover, for example. The HRUs established within previous model were generally maintained within the 2008 model; however, the clay soil (low infiltration) HRU from the original modeling was modified to reflect the silty soils located within the study area since no clays are present. Additional geotechnical information has been compiled as a component of the ongoing work within the Study Area and major revisions to the soil distribution throughout the subwatershed were warranted to incorporate that information.

B.1.5 SUBCATCHMENT GEOMETRY

The additional breakdown of subcatchments, as described in Section B.1.3, required revisions to the geometry (i.e. length and width) of each subcatchment from those assumed in the 2001 model delineation. For instance, the lengths of subcatchments farther from a river were extended in order to better approximate overland flow. In other words, if a particular subcatchment is no longer directly tributary to a watercourse, as a result of being delineated based on land use and not drainage, the overland travel distances must be made longer to match runoff and infiltration values from the original 2001 subcatchment, to maintain the original validated response characteristics. Modeling revisions such as these reflect physical reality given that a subcatchment located farther away does, in fact, flow over a subcatchment closer to the river, where the potential for further infiltration exists.

In previous applications of GAWSER, the overland flow basetime factor (FTB) has been set at 2 for rural catchments. However, for swampy or hummocky topography dominated subcatchments, FTB is set between 3 and 5. For urban subcatchments, i.e. those with imperviousness greater than 10%, FTB is set equal to 1.2. All of the above are consistent with previous modeling.

A typical off-channel and main channel section was used for all rural subcatchments. For urban subcatchments representative ‘sheet flow’ cross-sections were used for both the main and off channels. The slopes for each subcatchment within the Study Area were determined using methods outlined in the GAWSER Reference Manual. Catchment slopes were updated for all catchments within the Study Area, as well as Catchment 140, according to detailed topographic survey information.

B.1.6 CREEK CHANNEL DATA

There were no changes made to the Creek channel data, such as lengths, slopes, and cross sections used for both overland and channel routing. Additional channels were added to route flows from new subcatchments that were located distant to the creek.
B.1.7 TREATMENT OF DISTINCT HYDROLOGIC FEATURES

All distinct hydrologic features within the watershed such as ponds, swamps, and marshes were considered as separate reservoir or pond elements. Many of these hydrologic features were updated based on new information. The same modeling process (ROUTE SPECIAL POND) was used to model hummocky topography, which are now based on topographic data using a 1 m contour interval, allowing a much more accurate representation of these areas than in the 2001 model, within which storage characteristics were based on 5 m contour interval data. Based on the new topographic data, some hummocky areas were eliminated and others were made smaller resulting in surface runoff to Blair Creek during some medium to large size events. The stage-storage-discharge relationships for the storage areas upstream of New Dundee Road and Highway 401 have also been updated based on the new topographic information. Some of the water infiltrated within Depression Area 26, located at the southeast limit of Catchment 101, is collected by a tile drain and outlets as surface flow from the catchment. Based on available flow information for this tile drain, the surface flow from Catchment 101 is assumed to be a maximum of 10 L/s for the 5-year to 100-year flood event events.

B.1.8 TREATMENT OF GROUNDWATER SEEPAGE AND DISCHARGE

Several revisions were incorporated with regard to the groundwater modeling system; however, the locations where groundwater entered and left the storage array were maintained consistent with the 2001 model. In general, those drainage subcatchments contributing to the intermediate groundwater storage array (hummocky areas) were constant between models. The exception to this was subcatchment 108 that, upon review of more detailed topographic information, contains no internally drained, hummocky area. When a subcatchment was divided into smaller subcatchments, the groundwater characteristics of the original subcatchment were maintained.

GAWSER splits the groundwater system into three components: local, intermediate, and regional groundwater flow. Local groundwater flow represents water that falls on a subcatchment, infiltrates, and discharges to the surface system within the same subcatchment. Interflow or baseflow are examples of local groundwater flow. Intermediate groundwater flow represents water that falls within a given subcatchment, infiltrates, and discharges at a point downstream in the watershed. Regional groundwater flow represents water travelling between watersheds with relatively long residence times, and is essentially “lost” from the model once infiltrated.

The 2001 continuous simulation model assumes that there is no additional travel time associated with the movement of intermediate groundwater flow when compared to local groundwater flow, even though it must travel a substantially longer distance. When water infiltrates upstream, the model assumes that there is an almost instantaneous pressure wave that travels downstream and causes water to discharge at the same rate that it infiltrates into the intermediate groundwater aquifer. Literature indicates that such behaviour is possible in a confined aquifer (Kruseman and Ridder, 2000). The change of hydraulic head propagates rapidly because the release of water from storage is entirely due to the compressibility of the aquifer material and that of the water. Thus, hydraulic head changes can be seen at great distances at an almost instantaneous rate as the pressure wave travels quickly. However, in
unconfined aquifers such as that found the Blair Creek watershed, a change in hydraulic head propagates slowly given that the travel speed is dependant on the hydraulic conductivity of the intermediate soil.

Figure B.1 illustrates the difference that variations in the linear reservoir lag (also called the travel time or recession constant) can have on modeled flows. The 2001 continuous model included no additional travel time for intermediate flows and used the default value for local flows in GAWSER of 384 hours. During wet periods of the year (e.g. February-May, 1999 – shown below), the modeled baseflow increases to 0.3 m³/s, while the observed baseflow is constant at 0.19 m³/s. Later, during a dry period (June-September, 1999), the modeled baseflow decreases to 0.14 m³/s, while the observed baseflow remains near 0.18 m³/s. There is some seasonal variation in the observed baseflow but it is within in the order of 0.02 m³/s, while the baseflow predicted by the 2001 modeling, assuming a short groundwater travel time, varied by close to 0.2 m³/s.

The groundwater system in GAWSER is now modeled by using a constant groundwater flow to more closely match observed flows. Seasonal variation has been removed in favour of a constant baseflow of 0.165 m³/s (assumed to represent deep groundwater baseflow from inside and outside of the Blair Creek Watershed) from Roseville Swamp. The constant baseflow is based on the average baseflow at Dickie Settlement Road. This was found to even out the baseflow fluctuations in the 2001 model and more closely match the observed data. In reality there will be some seasonal and annual variation in baseflow but, given the constraints of the available data and the model, a constant value was found to fit the observed data best.

Groundwater fractions (the fraction of water infiltrated within a catchment that becomes deep groundwater and does not return as surface water within the catchment boundary) were updated for all catchments upstream of Highway 401 according to detailed geotechnical information of the area and assumed groundwater flow characteristics. The groundwater fraction was assumed as an average annual value. The value at any particular time of year can vary significantly from the average annual value depending on local groundwater characteristics.
B.1.9 SEASONAL PARAMETER ADJUSTMENTS

GAWSER permits a seasonal variation of soil parameters, such as depression storage and surface infiltration. The existing conditions model obtained from Schroeter & Associates contained different seasonal variations than those published in Table 2.3.7 of the 2001 report. The parameters that have changed are:

- Effective hydraulic conductivity factor (for surface infiltration)
- New snow relative density adjustment factor
- Potential evapotranspiration adjustment factor
- Some soil parameters including rate of infiltration and soil layer thicknesses

The parameters used in the 2008 Stantec model are equivalent to those in the most up-to-date model received from Schroeter & Associates. When this parameter set was used with the 2001 model, the results matched those in the 2001 report for the Chicago storm and short-term event simulations; however, some variation was observed when modeling long-term continuous simulations. This 2008 parameter set is believed to be more current and produce better results than the older parameter set, and be reflective of changes in the GAWSER program.
The 2001 modeling set the daily evapotranspiration rate to 1.03 mm/day. Based on further discussion with Schroeter & Associates and a comparison to average annual evapotranspiration rates for similar land types the daily evaporation rate was lowered to 0.9 mm/day.
B.2 Model Validation (Existing Conditions)

The 2001 Blair Creek Watershed Hydrology Model report stated that modeling completed was adequately validated, meaning that the predicted response to known rainfall events match the observed response to a reasonable degree of accuracy. In recognition of the significant revisions to the existing conditions model, as outlined in Section B.1, a direct comparison between the 2001 and 2008 model will yield different results. The following sections detail the comparison procedure undertaken and the evaluation of the results.

GAWSER is an evolving program, being maintained and updated on a regular basis by Schroeter & Associates. An example of this evolution is the ROUTE SPECIAL POND command, which was originally developed to model kettle ponds in Southern Ontario but has been adapted in this study to model hummocky topography. While an effort has been made to make GAWSER backwards compatible, difficulties invariably arise trying to reproduce similar results using different versions of the program. GAWSER version 6.9.7 was used for the 2008 Stantec model while an older version was used for the data in the 2001 report. The Chicago Storm and 1-2 week event simulations produced similar results; however, the long-term continuous simulation did show some difference, with the most noticeable being an increase in runoff. Long-term simulations allow for a small change in runoff and infiltration on an event basis to accumulate over time to form large changes over a year.

Discussions with Schroeter & Associates have concluded that many revisions have taken place to the model since the 2001 study, and that it is reasonable to expect that GAWSER version 6.9.7 could yield slightly different results. One change of note is that the depression storage for impervious areas had previously changed seasonally along with all the other hydrologic response units, whereas it is now fixed at a constant rate throughout the year. Changes have also occurred to the initial soil parameters and the seasonal variation of these parameters since the completion of the 2001 work. These have been updated over the past 7 years and represent a more current parameter set. This will affect the long-term water balance and result in observed variations from the 2001 report values.

B.2.1 COMPARISON EVENTS

Three different modeling approaches were undertaken to compare the 2001 and 2008 models, representing a range of storm magnitudes and parameters of interest. The data sets used were selected to match the events used for the 2001 model, and include:

- **Observed Event Modeling** - a 2-year continuous simulation between July 1998 and May 2000 using temperature, precipitation and observed flow data, for confirmation of response to “typical” events

- **Single Event Modeling** - the 4-hour duration, Chicago distribution return-period events for the Preston WPCP AES station (25 mm, 2-year, 5-year, 10-year, 25-year, 50-year, 100-year), and the Regional Storm, for analysis of predicted peak flows
Continuous Simulation Modeling - a 39-yr simulation employing using observed temperature and precipitation data for analysis of numerous statistical hydrologic characteristics such as annual water balance, erosion potential (duration of critical flow exceedance), low-flows, and mean daily discharges.

Streamflow data collected from July 1998 to May 2000 at New Dundee and Dickie Settlement Road was utilized in simulations spanning 1-2 week periods, the results of which were compared to measured flows. The 2008 Study ran the 2-year simulation as one continuous event using catchment parameters equivalent to those incorporated within the 39-year simulation. There were no precipitation gauges in Blair Creek during this period, so gauges from adjacent areas were employed. The 2001 Study scaled precipitation qualitatively using weather radar data (a visual comparison was made between the gauge location and the watershed location). No precipitation scaling was required during the 2008 study as the model results adequately reflected observed data without requiring such data manipulation measures.

The Chicago Storms represent the shortest simulations where the modeled periods lasted for one day. Initial conditions assumed a starting outflow from groundwater storage of 0.05 m³/s (baseflow) and soil parameters consistent with an October or November event. It was also assumed that hummocky areas were always wet, that evaporation was 1.55 mm/day.

The 39-year simulation uses temperature and precipitation data from Preston, Ontario, collected between 1960 and 1999. While this gauge is not within the modeled watershed, it is located directly beside it on the Grand River. Initial conditions assumptions included an outflow from groundwater storage of 0.05 m³/s; hummocky areas could dry out, that soil properties could vary seasonally, and that evaporation was 0.90 mm/day. The evaporation rate was determined based on values used in the 2001 modeling and on advice from Schroeter and Associates.

B.2.2 OBSERVED EVENT MODELING RESULTS AND DISCUSSION

The observed event modeling methodology was revised between the 2001 and 2008 models. In 2001, the events were run as 1-2 week events where initial soil moisture and base flow were specified. In the 2008 modeling, the simulation was run as one continuous event over the 2-year period of observed flows. An initial 7-month period was added to the event so that the model would reach equilibrium prior to the 1999 events.

A multi-event comparison has been undertaken partially as a means of “mitigating” the inherent error associated with the lack of meteorological data within the watershed of interest. Lacking a precipitation gauge within the Upper Blair Creek subwatershed, the model validation work utilized rainfall data from nearby stations and, therefore, may not be entirely representative of the events that occurred within the watershed. While slow-moving rainfall events of longer duration could be expected to generate similar hyetographs from one subwatershed to another, thunderstorm events or runoff events including a snowmelt component can differ substantially.

Observed and simulated hydrographs at New Dundee and Dickie Settlement Roads were compared for several events representing a range of depths and/or seasonal characteristics. In other words, rather than adjusting model parameters to exactly match the response of a single
event, a multi-event, qualitative comparison approach to determine an input parameter set producing the “best fit” across a range of rainfall conditions was undertaken.

July – October 1999

The model does an acceptable job of modeling flows at New Dundee Road, with the observed hydrographs showing few peaks and appearing to be dominated by base flows, as expected. Only during very wet periods is any significant surface runoff observed. During some rainfall events the model predicts runoff, where none is apparent in the observed flow data set. This may be the result of an incorrect impervious area as mentioned in Schroeter’s 2001 work, or simply that the rainfall event recorded in Preston was not experienced in the Upper Blair watershed. Modeled baseflows are generally within 0.02 m$^3$/s of observed baseflows. Figure B.2 illustrates a portion of a longer-term simulation at Dickie Settlement Road. Generally, the model does a good job of modeling baseflows and peaks, with discrepancies in peak flows thought to be the result of poor precipitation data.

![Figure B.2 Observed and Simulated Hydrographs from July to October, 1999](image-url)
November 10-11, 1998

The observed flows at New Dundee Road show no change during the November 10-11, 1998 rainfall event (constant flow of approximately 1.5 L/s), while there is a small change in modeled flow (peaks at 31 L/s). Schroeter & Associates suggested this might be due to an overestimation of the impervious area. It may also be due to the difficulties of modeling low flows on a large watershed with large portions of hummocky topography. The major rainfall event during this time period consisted of 22 mm of precipitation, yet there was no noticeable runoff in the observed flows. The watershed was very dry before this event, having experienced no precipitation for 2 weeks, and these conditions may not have been adequately modeled. The 2008 model results compare well to the 2001 model (equivalent peak flow rate).

The response further downstream at Dickie Settlement Road was, as expected, more pronounced, and the hydrographs provided in Figure B.3 indicate good agreement between observed and modeled flows at this location.

![Graph showing hydrographs for November 10-11, 1998 at Dickie Settlement Road](image)

Figure B.3: Hydrographs for November 10-11, 1998 – Dickie Settlement Road
February 23-24, 2000

The February 23-24, 2000, event was the only event that modeled snowpack melting with temperatures well above freezing and 18.4 mm of rainfall recorded. Although it would be expected that there would be measurable runoff during this event, given the relatively impervious character of surface soils at this point in the season, no flow changes were observed at New Dundee Road. It is suggested that the lack of observed runoff is likely due to ice blocking the river or possibly the gauge.

Figure B.4 illustrates the observed and modeled flows at Dickie Settlement Road for the February 23-24, 2000 event, with the modeled hydrograph predicting peak flow significantly lower than observed. This is possibly due to the difficulty in measuring snowfall and precipitation. This is the first large snowmelt of 2000 and it is possible that snowfall accumulation was not measured correctly during the winter. Though results from the 2001 study showed a closer correlation, the precipitation in that analysis was multiplied by a factor of 2.5. No manipulation of the precipitation data is employed within the 2008 modeling. The observed flows were lagged by 24 hours in a manner similar to that employed within the 2001 study.

![Graph showing modeled and observed flows](image-url)

**Figure B.4: Hydrographs for February 24, 2000 Event – Dickie Settlement Road**
May 2000 Events

Observed and modeled hydrographs for the May 2000 events are illustrated in Figures B.5 and B.6, and clearly show four hydrograph peaks at both New Dundee Road and Dickie Settlement Road. Approximately the same volume of precipitation fell during each of the four rainfall events. The major differences between the events in question were that the first rainfall event occurred after a long dry period (2 weeks) while the last rainfall event was spread over a 2-day period. At New Dundee Road, the first peak shows excellent agreement between modeled and observed flows while the second, third, and forth events are higher than the observed flows. At Dickie Settlement Road, the second and fourth peaks are modeled correctly while the first peak is less than observed flows and the forth peak is higher than observed flows. Assuming that the precipitation data is correct, a logical conclusion is that the model is incorrectly predicting antecedent moisture conditions.

Notwithstanding the above, the differences are also readily explainable if the precipitation data is not accurate. Use of another precipitation gauge from the area to model flows at Dickie Settlement Road, including more precipitation during the first event, and a shorter rainfall duration for the fourth hyetograph, the first and fourth peaks were modeled well while the second hydrograph was overestimated. Spatial variation of precipitation can influence the modeled results. The observed flows were lagged by 12 hours at Dickie Settlement Road in a manner similar to the 2001 study.
Figure B.6: Hydrographs for May 2000 – Dickie Settlement Road

B.2.3 SINGLE EVENT MODELING RESULTS AND DISCUSSION

Four-hour duration Chicago distribution storms were modeled for the 25 mm first flush and 2-year through 100-year events, in addition to the Regional Storm, in order to compare the 2001 and 2008 models predictions for peak flow generation. Continuity between the 2001 and 2008 models was maintained wherever possible when initializing the two models. Significant changes have been made to the modeling including changes in soil distribution, subcatchment slope, subcatchment delineation, the method of modeling groundwater flow, and the reduction/removal of hummocky topography, as described in Sections B.1.3 to B.1.7. The 2008 model is now significantly different from the 2001 model and direct comparison will be difficult.

Comparison of peak flows between the 2001 and 2008 models at several gauge locations for the 2-year and 100-year return-period events, and the Regional Storm is provided on Table B.2. Flows generally increase during all storm events at all locations along Blair Creek. The only location where a flow decrease is seen is at the outlet from Roseville Swamp. Most of this area was not changed between the 2001 and 2008 models since this area is outside of the study area. Only the soil distribution within Roseville Swamp and the method of groundwater flow modeling were changed and account for these flow differences.
Table B.2: Comparison of Peak Flows from 2001 and 2007 Single Event Models

<table>
<thead>
<tr>
<th>Flow Comparison Point</th>
<th>Change in Drainage Area (%)</th>
<th>Modeled Storm Flows (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2-Year</td>
</tr>
<tr>
<td>Reidel Drive</td>
<td>-8.7</td>
<td>0.01</td>
</tr>
<tr>
<td>New Dundee Road</td>
<td>-2.0</td>
<td>0.17</td>
</tr>
<tr>
<td>Reichert Drive, Old Gauge 1</td>
<td>-3.6</td>
<td>0.20</td>
</tr>
<tr>
<td>Roseville Swamp, Old Gauge 2</td>
<td>0.0</td>
<td>0.38</td>
</tr>
<tr>
<td>Hwy 401</td>
<td>-2.6</td>
<td>0.51</td>
</tr>
<tr>
<td>Dickie Settlement Road</td>
<td>-2.1</td>
<td>0.61</td>
</tr>
<tr>
<td>Old Mill Road</td>
<td>-1.8</td>
<td>0.72</td>
</tr>
</tbody>
</table>

B.2.4 CONTINUOUS MODELING RESULTS AND DISCUSSION

Operation of GAWSER in continuous simulation mode, using a meteorological data set spanning 39 years (1960-1999), was completed to analyze a number of statistical hydrologic characteristics such as annual water balance, duration of critical erosion flows, periods of low-flow, and mean daily discharge.

Water Balance

Water balance analysis was completed to compare the 2001 and 2008 models with respect to the predicted conversion of precipitation (P) to evapotranspiration (ET) (includes sublimation), surface runoff (R), and infiltration (I) within the Study Area. The GAWSER hydrologic model incorporates a further breakdown of the infiltration component to account for the variable routes that groundwater may follow. Infiltrated groundwater volumes are stored in a Groundwater Diversion Array and are either discharged back to the surface within the watershed as Baseflow (B) or, for those volumes that do not re-emerge within the area of interest, “lost” to Net Storage (S). The combination of Runoff and Baseflow represents all the water that leaves the subcatchment by surface flow and is denoted as the Total Flow. When GAWSER is utilized as a continuous simulation, it is possible to calculate a yearly water balance at various points in the watershed.

By corollary to the “losing” of water from a particular subwatershed of interest, watersheds can include discharge points for groundwater volumes that were infiltrated outside of the watershed of interest. Indeed, this is the case within the subject lands where groundwater that was infiltrated outside of the Upper Blair watershed discharges to the Creek system through the Roseville Swamp at a constant rate. The modeling assumes a constant baseflow of 0.165 m³/s which is assumed to include approximately 0.140 m³/s from outside of the watershed and 0.025 m³/s from intermediate groundwater flow from within Blair Creek. Contributions to Baseflow, then, can include regional, intermediate, or local groundwater flow.
In general, the differences in the predicted water balances between the 2001 and 2008 models are significant as indicated on Table B.3. The reduction in Evapotranspiration is largely attributable to changing the daily evaporation rate from 1.03 mm/day to 0.90 mm/day. Runoff increases are primarily caused by changing soil parameters, reduced hummocky storage volumes, and increases in subcatchment slopes.

### Table B.3: Water Balance Estimates

<table>
<thead>
<tr>
<th>Location</th>
<th>Scenario</th>
<th>Precip (mm)</th>
<th>ET (mm)</th>
<th>Runoff (mm)</th>
<th>Baseflow (mm)</th>
<th>Net Storage (mm)</th>
<th>Total Flow (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reidel Drive</td>
<td>2001 Model</td>
<td>882.1</td>
<td>624.8</td>
<td>3.8</td>
<td>0.26</td>
<td>253.2</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>2008 Model</td>
<td>882.1</td>
<td>577.1</td>
<td>72.7</td>
<td>62.92</td>
<td>169.3</td>
<td>135.6</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.0</td>
<td>-47.6</td>
<td>68.9</td>
<td>62.7</td>
<td>-83.9</td>
<td>131.5</td>
</tr>
<tr>
<td>New Dundee Road</td>
<td>2001 Model</td>
<td>882.1</td>
<td>613.8</td>
<td>32.6</td>
<td>34.8</td>
<td>200.8</td>
<td>67.5</td>
</tr>
<tr>
<td></td>
<td>2008 Model</td>
<td>882.1</td>
<td>573.6</td>
<td>75.4</td>
<td>78.5</td>
<td>154.6</td>
<td>153.8</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.0</td>
<td>-40.2</td>
<td>42.8</td>
<td>43.6</td>
<td>-46.3</td>
<td>86.4</td>
</tr>
<tr>
<td>Dickie Settlement Road</td>
<td>2001 Model</td>
<td>882.1</td>
<td>589.8</td>
<td>102.8</td>
<td>510.1</td>
<td>-320.5</td>
<td>612.8</td>
</tr>
<tr>
<td></td>
<td>2008 Model</td>
<td>882.1</td>
<td>573.4</td>
<td>76.2</td>
<td>475.2</td>
<td>-242.8</td>
<td>551.4</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.0</td>
<td>-16.4</td>
<td>-26.6</td>
<td>-34.8</td>
<td>77.7</td>
<td>-61.4</td>
</tr>
<tr>
<td>Old Mill Road</td>
<td>2001 Model</td>
<td>882.1</td>
<td>593.6</td>
<td>96.5</td>
<td>448.4</td>
<td>-256.4</td>
<td>544.9</td>
</tr>
<tr>
<td></td>
<td>2008 Model</td>
<td>882.1</td>
<td>574.2</td>
<td>73.1</td>
<td>420.5</td>
<td>-185.7</td>
<td>493.6</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.0</td>
<td>-19.3</td>
<td>-23.4</td>
<td>-28.0</td>
<td>70.7</td>
<td>-51.3</td>
</tr>
</tbody>
</table>

**Erosion Potential Analysis**

Erosion potential analysis, consisting of a statistical tracking of frequency and duration that streamflows are predicted to be above a certain critical erosive flow, was completed. As per the BBB Study, the Dickie Settlement Road crossing was utilized as the key comparison location, and a threshold flow rate of 0.4 m³/s was considered to represent the lower limit of the erosive flow regime. Table B.4 provides a summary of the existing condition flow duration analysis.

The variations between the 2001 and 2008 models are attributable to:

- Updates to the GAWSER modeling software
- Incorporation of the revised groundwater modeling method
- Elimination of some of the hummocky topography
- Modification of the storage reservoir upstream of Highway 401
- Revisions to soil parameter definition
Table B.4:
Existing Conditions Flow Duration Analysis
at Dickie Settlement Road

<table>
<thead>
<tr>
<th>Month</th>
<th>2001 Model (hrs &gt; 0.4 m³/s)</th>
<th>2008 Model (hrs &gt; 0.4 m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>45.8</td>
<td>20.1</td>
</tr>
<tr>
<td>February</td>
<td>44.9</td>
<td>30.8</td>
</tr>
<tr>
<td>March</td>
<td>165.5</td>
<td>105.9</td>
</tr>
<tr>
<td>April</td>
<td>134.7</td>
<td>79.4</td>
</tr>
<tr>
<td>May</td>
<td>144.7</td>
<td>17.6</td>
</tr>
<tr>
<td>June</td>
<td>31.9</td>
<td>6.6</td>
</tr>
<tr>
<td>July</td>
<td>7.9</td>
<td>4.9</td>
</tr>
<tr>
<td>August</td>
<td>10.4</td>
<td>6.0</td>
</tr>
<tr>
<td>September</td>
<td>15.2</td>
<td>6.4</td>
</tr>
<tr>
<td>October</td>
<td>44.6</td>
<td>12.1</td>
</tr>
<tr>
<td>November</td>
<td>83.7</td>
<td>33.8</td>
</tr>
<tr>
<td>December</td>
<td>65.6</td>
<td>35.8</td>
</tr>
<tr>
<td>Total</td>
<td>795.0</td>
<td>359.4</td>
</tr>
</tbody>
</table>

7-Day Low Flows

Low flows generally increased at Dickie Settlement Road using the 2008 model, as shown in Table B.5, a result that is attributable to the modified method of groundwater modeling as previously discussed in Section B.1.8.

Table B.5:
Summary of 7-Day Low Flow Estimates - 2001 versus 2007

<table>
<thead>
<tr>
<th>Location</th>
<th>Scenario</th>
<th>2-Year</th>
<th>5-Year</th>
<th>10-Year</th>
<th>20-Year</th>
<th>100-Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dickie Settlement Road</td>
<td>2001 Model - Existing</td>
<td>0.16</td>
<td>0.14</td>
<td>0.14</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>2008 Model - Existing</td>
<td>0.17</td>
<td>0.17</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.01</td>
<td>0.03</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Table B.6 provides the minimum 7-day low flow estimates for an extreme dry year and a wet year. The minimum 7-day low flow was calculated for each calendar year over the 39-year simulation and the range of extreme dry and wet years is presented. Predicted low flows increased from the 2001 to the 2008 models, again as a result of revisions to the method of modeling groundwater seepage and discharge, as described above.

Table B.6:
Existing Conditions 7-Day Low-Flow Estimates – Extreme Dry & Wet Years

<table>
<thead>
<tr>
<th>Location</th>
<th>Scenario</th>
<th>7-Day Low-Flow Range (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dickie Settlement Road</td>
<td>2001 Model</td>
<td>0.142 – 0.201</td>
</tr>
<tr>
<td></td>
<td>2008 Model</td>
<td>0.165 – 0.185</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>0.023 – 0.016</td>
</tr>
</tbody>
</table>

Mean Daily Discharge

Table B.7 provides a summary of the mean daily discharge results under existing conditions at New Dundee Road and Dickie Settlement Road. The results generally show an increase in the predicted mean daily discharge estimated using the 2008 model at New Dundee Road and a decrease at Dickie Settlement Road, again as a result of the revised groundwater modeling method incorporated into the current model, serving to prolong the response time from events through slower release of baseflow, as described above.

Table B.7:
Existing Conditions Mean Daily Discharge Comparison

<table>
<thead>
<tr>
<th>Percentage of Time Equalled or Exceeded</th>
<th>New Dundee Road</th>
<th>Dickie Settlement Road</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>90%</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>80%</td>
<td>0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>70%</td>
<td>0.003</td>
<td>0.005</td>
</tr>
<tr>
<td>60%</td>
<td>0.005</td>
<td>0.007</td>
</tr>
<tr>
<td>50%</td>
<td>0.007</td>
<td>0.011</td>
</tr>
<tr>
<td>40%</td>
<td>0.008</td>
<td>0.017</td>
</tr>
<tr>
<td>30%</td>
<td>0.010</td>
<td>0.023</td>
</tr>
<tr>
<td>20%</td>
<td>0.011</td>
<td>0.030</td>
</tr>
<tr>
<td>10%</td>
<td>0.015</td>
<td>0.040</td>
</tr>
</tbody>
</table>

Mean Daily Discharge
Flood Frequency Analysis

Flood frequency analysis using the 3 Parameter Log Normal (3-PLN) distribution was performed on the stream flows to determine return period flows based on the continuous simulation. The 3-PLN distribution uses annual flood flows to determine return period flows and has been recommend by the Ministry of Transportation for frequency analysis in Ontario.

Table B.8 provides a summary of the return period flows calculated using the continuous simulation flows at Reidel Drive, New Dundee Road, and Dickie Settlement Road. The continuous simulation results are generally higher than the event model results with a larger increase seen during lower flow events. The inclusion of snow melt events in the continuous simulation and the seasonal differences in soil characteristics (e.g., initial soil moisture, soil permeability) between the event modeling and those observed during the peak flows in the continuous simulation are largely responsible for the majority of the flow increase. The peak flows during a given year generally occur in the winter months, between November and May, with the most common months being December, March, and April. The peak flow timing is coincident with snow melt events and periods of the year when the soil is saturated or frozen.

<table>
<thead>
<tr>
<th>Flow Comparison Point</th>
<th>Modeled Storm Flows (m$^3$/s)</th>
<th>2-Year</th>
<th>5-Year</th>
<th>1-Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Event Cont. Δ Event Cont. Δ Event Cont. Δ</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reidel Drive</td>
<td>0.01 0.32 0.31 0.15 0.51 0.36</td>
<td>0.60 0.94 0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Dundee Road</td>
<td>0.23 0.67 0.44 0.47 0.94 0.48</td>
<td>1.27 1.48 0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dickie Settlement Road</td>
<td>1.06 2.26 1.20 2.18 3.06 0.88</td>
<td>5.78 4.54 -1.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old Mill Road</td>
<td>1.19 2.60 1.41 2.52 3.60 1.08</td>
<td>7.10 5.43 -1.67</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B.2.5 STATISTICAL ANALYSIS RESULTS AND DISCUSSION

The 2008 model has changed significantly from the 2001 model and direct comparison is no longer appropriate. The reliability of the 2008 and 2001 models has been assessed using different goodness of fit criteria to compare the modeled flow to observed.

The criteria used include deviation of runoff volumes (Dv), the absolute percent bias (APB), the root mean squared error (RMSE), the mean absolute error (MAE), the bias (b), the Nash-Sutcliffe coefficient (N_r), and the correlation coefficient (R).
**Deviation of Runoff Volumes (Dv)**

The deviation of runoff volumes Dv, also known as the percentage bias, is perhaps the simplest goodness-fit criterion. Its value is calculated using equation 1:

\[
D_v(\%) = \left( \frac{\sum_{i=1}^{N} (S_i - O_i)}{\sum_{i=1}^{N} O_i} \right) * 100
\]

where \( S_i \) is the simulated discharge for each time step and \( O_i \) is the observed value. \( N \) is the total number of values within the period of analysis. For a perfect model, \( D_v \) is equal to zero. The smaller the \( D_v \) value, the better the performance of the model.

**Absolute Percent Bias (APB)**

The absolute percent bias is a measure of the timing difference between the stream flow observations and the model simulations. It is usually used in conjunction with the \( D_v \) criterion. Given an observed and simulated series where the \( D_v \) value is small and the APB is large, one could conclude that both series share similar volumes but that their timing is not as close. Thus, a good agreement in timing and volume requires \( D_v \) and APB to be small. APB is always greater than \( D_v \), and its value is determined using equation 2:

\[
APB(\%) = \left( \frac{\sum_{i=1}^{N} |S_i - O_i|}{\sum_{i=1}^{N} O_i} \right) * 100
\]

where all values have the same meaning as in equation 1.

**Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Bias (b)**

These three indicators provide a quantitative estimate of the differences between models in units of discharge (m³/s). The values of these three criteria are used to establish a relative comparison of the modeled flows. RMSE, MAE, and b are calculated using equations 3 to 5:

\[
RMSE = \left[ \frac{1}{N} \sum_{i=1}^{N} (S_i - O_i)^2 \right]^{1/2}
\]

\[
MAE = \frac{\sum_{i=1}^{N} |S_i - O_i|}{N}
\]

\[
b = \frac{\sum_{i=1}^{N} (S_i - O_i)}{N}
\]

where all the terms have the same meaning as above.
Nash-Sutcliffe Coefficient (N_r)

Along with the coefficient of correlation, the Nash-Sutcliffe coefficient (N_r) is a measure of statistical association, which indicates the percentage of the observed variance that is explained by the predicted data. The Nash-Sutcliffe coefficient, also known as the efficiency criterion, is perhaps the most common measurement mentioned in the hydrological literature for evaluating the performance of a model. N_r is estimated using equation 6:

\[
N_r = 1 - \frac{\sum_{i=1}^{N} (O_i - \bar{O})^2}{\sum_{i=1}^{N} (O_i - O_i^*)^2}
\]

where \(O_i^*\) is the average measured discharge and all the other variables have the same meaning as above. The second term in equation 6 represents the ratio between the mean square error (MSE) and the variance of the observed data. Thus, a value of N_r equal to zero indicates that the model output is not better than that obtained using the simple averaged observed streamflow for the entire period of analysis.

A shortcoming of the Nash-Sutcliffe statistic is that, because of its definition, it puts more emphasis on extreme events than on average flows. Additionally, the timing of the predicted series greatly influences the value of the coefficient.

Correlation Coefficient (R)

The R statistic describes the degree of colinearity between the observed and predicted time series. R is determined as indicated in equation 7. A perfect model has a correlation coefficient equal to 1.0. High values of the R coefficient indicate better agreement between observations and simulations.

\[
R = \frac{\frac{1}{N} \sum_{i=1}^{N} (O_i - \bar{O})^* (S_i - \bar{S})}{\sqrt{\frac{N \sum_{i=1}^{N} O_i^2 - (\sum_{i=1}^{N} O_i)^2}{N(N-1)}} \sqrt{\frac{N \sum_{i=1}^{N} S_i^2 - (\sum_{i=1}^{N} S_i)^2}{N(N-1)}}}
\]

where all symbols have the same meanings as above.

As with the Nash-Sutcliffe statistic, the correlation coefficient is more sensitive to outliers than to values near the observed mean.

The seven values were calculated for the 2001 and 2008 models as compared to observed flows and are presented in Table B.9. In all cases the 2008 model is equivalent or improved when compared to the 2001 model.
### Table B.9: Goodness of Fit Comparison

<table>
<thead>
<tr>
<th></th>
<th>2001 Model</th>
<th>2008 Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deviation of Runoff Volumes (Dv)</td>
<td>11.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Absolute Percent Bias (APB)</td>
<td>26.4</td>
<td>16.6</td>
</tr>
<tr>
<td>Root Mean Square Error (RMSE)</td>
<td>0.115</td>
<td>0.106</td>
</tr>
<tr>
<td>Mean Absolute Error (MAE)</td>
<td>0.057</td>
<td>0.036</td>
</tr>
<tr>
<td>Bias (b)</td>
<td>0.024</td>
<td>0.008</td>
</tr>
<tr>
<td>Nash Sutcliffe Coefficient (N_r)</td>
<td>-0.610</td>
<td>-0.386</td>
</tr>
<tr>
<td>Correlation Coefficient (R)</td>
<td>0.428</td>
<td>0.428</td>
</tr>
</tbody>
</table>
B.3 Model Set-up for Proposed Development Scenarios

In Section B.2, it was illustrated that the 2008 model is reasonably similar to the 2001 model and observed flows. It is therefore concluded that the new model has been “validated”, and can be employed in assessing the impacts of the proposed land use changes on subwatershed hydrology.

Instead of repeating all of the earlier modeling scenarios, the “short list” of conditions to be evaluated in this report includes:

- Scenario 1 - Existing conditions (updated to reflect current understanding of watershed conditions 2008)
- Scenario 2 - Proposed conditions model from the earlier FDS work. This scenario has been updated to reflect the current state of knowledge of the watershed including geotechnical / hydrogeological and topographical conditions. Year round infiltration of runoff is still analyzed for the West Study Area
- Scenario 3 – Proposed conditions model developed through the OMB mediation process. This scenario also reflects the current state of watershed knowledge, considers a winter infiltration by-pass for all areas and mitigates erosion concerns by using a 96-hour extended detention drawdown for a 2-year storm event
- Scenario 4 – Scenario 3 proposed conditions model where only lands within the current urban boundary (east of Reidel Drive) are developed

A total of four distinct sets of development conditions were modeled, ranging from existing conditions to those proposed for implementation. The characteristics of each of the alternative scenarios investigated are summarized on Table 4.1 of the main report. All proposed conditions scenarios assumed impervious coverages in line with the Community Plan options under consideration. The impervious areas were increased by proportionately reducing the pervious areas. Revisions to percentage of impervious areas are shown in Table B.9.

A 39-year meteorological data sequence was applied to the model for determining long-term water balance quantities, extreme low flows, flow duration information, and critical flow exceedance times resulting from each scenario.

Groundwater fractions (the fraction of water infiltrated within a SWM facility that becomes deep groundwater and does not return as surface water within the catchment boundary) were determined for each SWM facility within the Study Area according to detailed geotechnical information of the area and assumed groundwater flow characteristics. The groundwater fraction was assumed as an average annual value. The value at any particular time of year can vary significantly from the average annual value depending on local groundwater characteristics.
### Table B.9: Changes in Impervious Land Cover

<table>
<thead>
<tr>
<th>Subcatchment</th>
<th>Existing Impervious Area (%)</th>
<th>Future Assumed Impervious Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>0.4</td>
<td>52.6</td>
</tr>
<tr>
<td>103</td>
<td>0.4</td>
<td>55.0</td>
</tr>
<tr>
<td>104</td>
<td>0.1</td>
<td>55.0</td>
</tr>
<tr>
<td>105</td>
<td>0.1</td>
<td>39.4</td>
</tr>
<tr>
<td>106</td>
<td>0.1</td>
<td>55.0</td>
</tr>
<tr>
<td>107</td>
<td>1.8</td>
<td>80.0</td>
</tr>
<tr>
<td>108</td>
<td>1.8</td>
<td>49.2</td>
</tr>
<tr>
<td>110</td>
<td>1.8</td>
<td>60.0</td>
</tr>
<tr>
<td>111</td>
<td>1.8</td>
<td>45.2</td>
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<tr>
<td>118</td>
<td>0.4</td>
<td>55.0</td>
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<tr>
<td>120</td>
<td>1.9</td>
<td>57.5</td>
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<td>122</td>
<td>1.3</td>
<td>55.0</td>
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<td>124</td>
<td>3.9</td>
<td>47.6</td>
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<tr>
<td>126</td>
<td>1.7</td>
<td>55.0</td>
</tr>
<tr>
<td>127</td>
<td>1.7</td>
<td>55.0</td>
</tr>
<tr>
<td>143</td>
<td>6.0</td>
<td>55.0</td>
</tr>
<tr>
<td>147</td>
<td>6.0</td>
<td>55.0</td>
</tr>
<tr>
<td>146</td>
<td>6.0</td>
<td>55.0</td>
</tr>
</tbody>
</table>
B.4 References


September 30, 2008
File: 1603-10697/10

City of Kitchener
City Hall Complex
200 King Street West
Kitchener ON N2G 4V6

Attention: Mr. Grant Murphy
Director of Engineering

Dear Mr. Murphy:

Reference: Upper Blair Functional Drainage Study
Regional Storm Control Scenarios
City of Kitchener

The following letter summarizes the sensitivity analysis performed on the Regional Storm Model in the Upper Blair Creek watershed to determine the feasibility of implementing a partial Regional Storm control scenario as one of the recommendations of the Functional Drainage Study (FDS). The following paragraphs outline the tasks undertaken and the respective results and conclusions.

The first task was to analyze the potential development density as directed by the Places to Grow requirements, and determine the equivalent impervious cover ratio for the Region of Waterloo’s target density of 55 persons and jobs per hectare. Our analysis considered two large tracts of land that would be similar in scale to the Upper Blair areas:

- Three contiguous subdivisions on the west side of Waterloo. Our understanding is that the density equates to about 55 persons and jobs per hectare, and the impervious cover is 55%
- An area in Cambridge adjacent to Townline Road as presented in the Region of Waterloo’s document Visualizing Densities Part II: Future Possibilities. The scenario with a density of 60 persons and jobs per hectare was determined to have an impervious cover of about 61%

The conclusion of this analysis is that the imperviousness modeled in the Upper Blair FDS would not increase significantly if urban density requirements were increased to achieve the 55 persons and jobs per hectare target.
The next task was to determine the sensitivity of Regional Storm flows to changes in impervious cover within the East Study Area. The West Study Area was assumed to control flows to the flow rates as agreed through the OMB mediation process as outlined in Table 1. The impervious percentage modeled was 55% in all areas since previous work concluded that flood elevations are not very sensitive to changes in impervious up to 75% in the East Study Area. Stormwater management facilities in the GAWSER model were modified from the FDS to remove Regional Storm controls from the East Study Area and change the percent impervious where required. The result - as expected - was an increase in Regional Storm flows in Blair Creek.

<table>
<thead>
<tr>
<th>Subcatchment ID</th>
<th>Subcatchment Area Current Conditions (ha)</th>
<th>Post-development Allowable Flow Rates (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>87.1</td>
<td>2.59</td>
</tr>
<tr>
<td>102</td>
<td>24.1</td>
<td>1.16</td>
</tr>
<tr>
<td>103</td>
<td>14.9</td>
<td>0.88</td>
</tr>
<tr>
<td>104</td>
<td>28.6</td>
<td>1.00</td>
</tr>
<tr>
<td>105</td>
<td>31.8</td>
<td>1.17</td>
</tr>
<tr>
<td>106</td>
<td>38.9</td>
<td>1.82</td>
</tr>
<tr>
<td>111</td>
<td>46.6</td>
<td>1.96</td>
</tr>
</tbody>
</table>

The final step was to determine the impact of these changes on the Blair Creek Regional Storm flood elevations, with particular attention to those locations where there were potential impacts to existing structures. The flows produced by the GAWSER model in the previous task were inserted into the HEC-RAS model version 4.0.0 and compared. The discussion below refers to the actual (modeled) flood elevations, not the Regulatory Flood Elevations. The results are summarized as follows:

- The removal of Regional Storm control requirements on the East Study Area resulted in an increase flood elevations in Blair Creek:
The increase was generally very minor - usually less than 0.1 m

Upstream of Highway 401 the model calculated an increase in flood elevation of about 0.2 m. While this does not directly impact any structures, the access to the Doon Soccer Club would be flooded deeper than under current conditions. The building itself (finished floor 299.94 m) is above the modeled flood elevations. Flood levels are summarized in Table 2.

No existing buildings are impacted by these changes in flood elevations.

Table 2
Regional Storm - Blair Creek Flood Elevation Comparison

<table>
<thead>
<tr>
<th>HEC-RAS Cross Section #</th>
<th>Section Location</th>
<th>Existing</th>
<th>Regulatory Event</th>
<th>Partial Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>6137</td>
<td>Reichert Drive* (2)</td>
<td>300.42</td>
<td>300.47</td>
<td>300.43</td>
</tr>
<tr>
<td>6123</td>
<td></td>
<td>300.25</td>
<td>300.27</td>
<td>300.25</td>
</tr>
<tr>
<td>6115</td>
<td></td>
<td>300.07</td>
<td>300.19</td>
<td>300.11</td>
</tr>
<tr>
<td>5935</td>
<td></td>
<td>300.05</td>
<td>300.15</td>
<td>300.09</td>
</tr>
<tr>
<td>5838</td>
<td></td>
<td>299.54</td>
<td>299.97</td>
<td>299.55</td>
</tr>
<tr>
<td>5662</td>
<td></td>
<td>299.24</td>
<td>299.92</td>
<td>299.41</td>
</tr>
<tr>
<td>5320</td>
<td></td>
<td>299.15</td>
<td>299.89</td>
<td>299.34</td>
</tr>
<tr>
<td>5159</td>
<td></td>
<td>299.10</td>
<td>299.87</td>
<td>299.30</td>
</tr>
<tr>
<td>5155</td>
<td>Soccer Club Culvert (3)</td>
<td>299.11</td>
<td>299.87</td>
<td>299.30</td>
</tr>
<tr>
<td>5146</td>
<td></td>
<td>299.10</td>
<td>299.87</td>
<td>299.30</td>
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<tr>
<td>5133</td>
<td></td>
<td>299.10</td>
<td>299.87</td>
<td>299.30</td>
</tr>
<tr>
<td>5079</td>
<td></td>
<td>299.10</td>
<td>299.86</td>
<td>299.30</td>
</tr>
<tr>
<td>5064</td>
<td>Highway 401(3)</td>
<td>299.05</td>
<td>299.83</td>
<td>299.25</td>
</tr>
</tbody>
</table>

Note:
1 Partial Regional Control means West Study Area (west of Reidel Drive) controls Regional Flows per FDS, East Study Area does not.
2 Flows at Reichert Drive include drainage from Roseville Swamp
3 Backwater effects of Highway 401 culvert
Since the Doon Soccer Club access road is the only structure significantly impacted by the changes in flood elevation, a more detailed summary is provided in Table 3. Regardless of the change in modeled flood elevation, there is currently no safe access for either residential or commercial uses under Regulatory Event conditions and, therefore there is no impact to the property from GRCA’s Floodplain Policy perspective.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Flood Elevation (m)</th>
<th>Minimum Elevation (m)</th>
<th>Flood Depth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>299.11</td>
<td>298.19</td>
<td>0.92</td>
</tr>
<tr>
<td>Regulatory Event</td>
<td>299.87</td>
<td>298.19</td>
<td>1.68</td>
</tr>
<tr>
<td>Partial Regional Control (55% impervious)</td>
<td>299.30</td>
<td>298.19</td>
<td>1.11</td>
</tr>
</tbody>
</table>

In summary, the Regional Storm sensitivity analysis concludes that:

- 55% impervious cover is an appropriate model assumption for the 55 persons and jobs per hectare development density
- Implementation of a partial Regional Storm control scenario where the East Study Area is not required to provide Regional Storm control and the West Study Area is required to provide Regional Storm controls to the FDS targets increases flows in Blair Creek
- The increased flows in Blair Creek result in minor impacts to flood elevations (not the Regulatory Limit) throughout the Upper Blair Creek watershed, with the most significant impacts occurring immediately upstream of the Highway 401 crossing

Because the changes in flood elevations are generally small, have little impact on existing building or structures (with the exception of the soccer club access road) and do not affect Regulatory Flood elevations, the implementation of the partial Regional Storm control scenario described herein would be acceptable to the agencies provided that the West Study Area provides Regional Storm control to limit rates as per Table 1 in the event it is brought into the City Urban Area at some future date.
September 30, 2008
Mr. Grant Murphy
Director of Engineering
Page 5 of 5

Reference: Upper Blair Functional Drainage Study
OMB Related Additional Modeling Work
City of Kitchener

I trust the foregoing is sufficient for your needs at this time. Should you have any questions, please do not hesitate to contact me at your convenience.

Sincerely,

STANTEC CONSULTING LTD.

Steve Brown, MBA, P.Eng
Senior Water Resources Engineer
Tel: (519) 585-7446
Fax: (519) 579-8664
steve.brown@stantec.com

Attachment

c. Ms. Fiona McCrea / Mr. Binu Korah, City of Kitchener
   Mr. Gus Rungis / Mr. Drew Cherry / Ms. Nancy Davy, Grand River Conservation Authority
   Mr. Don Corbett / Mr. Chris Gosselin, Region of Waterloo

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APPENDIX C

Environmental Scan of Stormwater
Best Management Practices
Summary of SWM BMP’s

1 Prevention

Perhaps the easiest and most effective means of mimicking pre-development hydrologic conditions would be to limit the extent of development thereby preventing or limiting the creation of a typical post-development hydrologic condition requiring management in the first place. Indeed, this approach is effectively that taken with the recommended implementation of maximum impervious cover limits (ICL’s) established through the Blair, Bechtel and Bauman Creek Subwatershed Plan (BBB SWP). This approach qualifies as a “Best Management Practice” toward stormwater management and is, therefore, worth pursuing herein.

The BBB SWP introduces the concept of ICL as follows: “Imperviousness is one of the few variables municipal authorities can plan for, quantify, manage, and control at each stage of the land development process. By controlling the amount of impervious area, municipal authorities are able to directly control the impacts of land development. At the same time, municipal subdivision / site plan codes should be flexible enough to allow developers to optimize densities at lower levels of imperviousness.” The practices outlined in this section are all capable of impacting the extent of post-development stormwater that is created. Varying degrees of “flexibility” will be required of the municipality and/or developer as some of the practices, though previously implemented in other jurisdictions, may not be considered ‘standard’.

1.1 Promotion of High Density Development

- high density development, such as apartment buildings, results in reduced road frontage and driveway required for equivalent number of units, dedicate more area to Open Space (reduces impervious coverage)

1.2 Alternative Development Standards

The greatest share of total impervious cover in most communities is from the roads, sidewalks, parking lots and driveways used to get us from where we work, live or shop. This reflects the strong influence the car has in shaping the design of our communities. The following practices aim to reduce the extent of impervious coverage, thereby representing an immediate SWM benefit of reduced runoff volumes and peak flows. For a complete discussion on the practices outlined in Sections 1.2.1 – 1.2.3, the interested reader should refer to Site Planning for Urban Stream Protection (Schueler, Tom), available on-line at http://www.cwp.org/.

1.2.1 Reduced Road Widths

- adoption of alternative development standards to allow the width of ‘headwater streets’ (as opposed to the wider and more heavily traveled roads and highways) to be reduced to reflect the actual anticipated traffic volumes (i.e. differentiate road standard based on anticipated vehicle trips – ‘headwater street’ considered to represent the access (500 to 1,000 average daily traffic (ADT)) and collector streets (1,000 to 3,000 ADT))
recent studies indicate that ‘headwater streets’ represent between 50 and 65% of the length of the entire road network, thereby offering substantial opportunity to reduce imperviousness (analysis shows reduction of 30-50% of road imperviousness achievable)

- reduction in impervious coverage reduces runoff volumes and peak flows

### 1.2.2 Reduced House Setbacks
- reduction in house setback from road right-of-way results in a reduction in driveway length required; therefore reduction in impervious coverage resulting from driveways directly proportional to reduction in minimum house setback
- reduction in impervious coverage reduces runoff volumes and peak flows

### 1.2.4 Alternative Turn-Around Standards for Dead-Ends
- Implementation of T-shaped or “hammerhead” type turnarounds, as opposed to circular cul-de-sac, offers significant impervious cover reductions (> 50%)
- May encounter resistance with essential services such as fire or snow removal
- Reduction in impervious coverage reduces runoff volumes and peak flows

## 2 Lot Level / At-Source Controls

Lot level controls are designed to treat surface runoff at the source, where rain falls to the ground. The control of stormwater at source is preferred in that the dispersed nature of the treatment system tends to mimic the behaviour of natural systems more closely than concentrating treatment in an end-of-pipe facility, for instance. Source controls are significant for reducing pollutant loads to local water bodies partially through their ability to promote the infiltration of runoff at the site, rather than having runoff leave the site, where sediments and other contaminants are normally picked up along the roadways and other conveyance routes. Source control measures can be structural or nonstructural in nature or may depend on soil characteristics, land use, size of individual lots, and municipal acceptance. Source control measures are particularly useful for their water quality benefit and ability to reduce downstream peak flows and should be recognized for their applicability in retrofit situations where other measures may be too land-intensive.

A study commissioned by the City of Toronto in 1999 presented a number of alternate measures that could be used for source control whether it is a residential, commercial, or industrial lot. The study suggested that municipalities should take a leadership role in showcasing innovative control measures and educating the public, and should encourage partnership and incentive programs where feasible (J.F. Sabourin & Associates, 1999).

A significant challenge in designing and implementing a stormwater management strategy which incorporates lot level techniques and other source controls is that many of these initiatives will be implemented on lands held in private ownership. Consequently, maintenance and the long-term effectiveness of the system is contingent on the actions of the landowner. Landowner education is the key to ensuring that systems remain effective over time. The successful application of lot level landscape solutions requires the commitment of the municipality and the establishment of creative partnerships between the developers, municipality and landowner to realize consistent benefits over the long term.
2.1 Structural

2.1.1 Downspout Disconnection
Average annual runoff from a typical residential roof could be used to flush a low flow toilet 12,000 times! (J.F. Sabourin and Associates, 1999)
- reduces volume of flow to sewer system and reduces size requirements for end-of-pipe facilities
- reduces frequency of basement flooding caused by sewer back-up
- reduces occurrence of combined sewer overflow (where applicable)
- promotes infiltration
- need for municipal incentive (i.e. disconnection free to residents) and development standards (i.e. by-laws) to require disconnection in new subdivisions

2.1.2 Rainbarrels
- promotes water conservation
- savings on utility bill – rain water can be used for watering lawns, gardens and indoor plants or for washing cars
- need for municipal incentives (i.e. cost recovery)

2.1.3 Backyard Ponds
- promotes water conservation
- reduces volume of flow to storm sewer system (if pond fed by downspout or rainbarrel)
- encourages wildlife habitat

2.1.4 Pervious Pavement
Comes in a variety of forms and is effective at reducing impervious surface; most appropriate in the ROW in low volume and low speed areas such as parking lanes and sidewalks.
- promotes infiltration and underground storage (bullets: Carruthers)
- reduces peak flow to sewer system through slow release

2.1.5 Tree and Vegetation Planting
- increases transpiration and evaporation rates as rainwater is captured by vegetation
- infiltration enhanced as plants absorb rainwater
- vegetation acts as a natural filter removing pollutants and absorbing nutrients

2.1.6 Rooftop Gardens
- reduces volume of runoff to sewer system (where roof leaders are connected)
- saves money by reducing utility bill for heating and air conditioning costs
- promotes improved air quality because of filtering effect of vegetation

2.1.7 Parking Lot and Rooftop Storage
- reduces downstream peak flows
- may reduce required sewer sizes therefore reducing overall infrastructure costs
- applicable for infill development
2.1.8 Reduced Lot Grading

- reduction of standard minimum lot grades from 2% to as low as 0.5% (Municipal Affairs and Housing, 1995)
- should be implemented where soils have percolation rates ≥ 15 mm/hr (generally soils coarser than loams)
- most applicable in areas where existing land is naturally flat, i.e. natural topography favours implementation
- general results are reduction in runoff volume and peaks, slowing of runoff velocity

2.1.9 Roof Leader to Ponding Areas

- provision of ponding areas, generally in the rear yards, to accept roof runoff discharged to the surface – water is detained until it either evaporates or infiltrates
- should be implemented where soils have percolation rates ≥ 15 mm/hr (generally soils coarser than loams)
- ponding volume equivalent to 5-20 mm runoff from the roof area should be provided
- general results are reduction in runoff volume and peaks, increased infiltration

2.1.10 Infiltration Galleries / Soakaway Pits (Private)

- direct connection of roof leader to underground infiltration trench (soakaway pit) comprised of clear stone (50 mm diameter) surrounded by filter cloth
- overflow bypass should discharge to surface where homeowner observation of by-pass frequency will alert to need for maintenance
- should be implemented where soils have percolation rates ≥ 15 mm/hr (generally soils coarser than loams)
- storage volume equivalent to 5-20 mm runoff from the roof area should be provided
- general results are reduction in runoff volume and peaks, increased infiltration

2.1.11 Infiltration Trenches

- connection of roof leaders to surface, draining to CB inlet to communal infiltration trench comprised of clear stone (50 mm diameter) surrounded by filter cloth – trench normally aligned along rear lot lines
- overflow bypass can be connected to storm sewer system with CB’s and MH suitable for inspection and/or maintenance of the system
- should be implemented where soils have percolation rates ≥ 15 mm/hr (generally soils coarser than loams)
- storage volume equivalent to 5-20 mm runoff from the roof and rear yard area should be provided
- general results are reduction in runoff volume and peaks, increased infiltration
2.2 Non-Structural

2.2.1 Lawn Aeration

• urban soils can often behave similar to paved surfaces from a hydrologic perspective due to compaction and can even produce more runoff (Schueler, 1995)
• enhances infiltration of runoff
• beneficial to root systems of vegetation and promotes improved growth potentially having the water quality benefit of reduced fertilizer / chemical usage

2.2.2 Litter and Animal Waste Collection

• requirement for municipal by-laws supported by enforcement (fines)
• public education to prevent littering by individuals and/or their pets shows most promise – post signage, provide containers
• garden / lawn litter also problematic – implement waste pick-up and/or composting programs
• reduces potential for water quality impacts and eutrophication in water bodies because of presence of oxygen demanding substances, nutrients, and faecal bacteria

2.2.3 Municipal By-Laws

• adoption of by-laws which support measures to clean up urban runoff (i.e. sewer use, topsoil preservation, erosion and sediment control, zoning, poop and scoop, water conservation)

2.2.4 Education / Public Relations

• municipalities should showcase alternative measures on municipal buildings / property
• need to educate residents regarding connection between their property and downstream water quality impacts – encourage environmental stewardship and lifestyle choices
• distribution of flyers, television and print ads, inserts in utility bills

2.2.5 Landscaping Practices

• Supreme Court of Canada has made it legally acceptable for municipalities to ban pesticide use on municipal and private properties (excluding golf courses)
• need for strict guidelines for use of pesticides on golf courses (i.e. license from the MOE)
• improve water quality through reduced use of pesticides and fertilizers on urban lawns – majority of people do not know the phosphorous or nitrogen content of the fertilizer they apply and only 10-20% take soil tests to determine whether or not their lawn needs fertilization at all (www.stormwatercenter.net)
• encourage lawn owners to compost grass clippings and leaves or to leave on the lawn to reduce the need for fertilizers
• encourage use of native species which are water and maintenance friendly
• encourage off peak watering and efficient water use
2.2.6 Road Maintenance and Street Sweeping Practices
- Roadways (collectors and residential feeder streets) contribute highest level of runoff-borne pollutants from impervious surfaces including *E.coli.*, sediments, cadmium and copper (Arnold and Gibbons, 1996)
- Municipal practices should be reviewed and modified to reflect environmental objectives
- Limit amount of de-icing chemicals or road salts applied during winter driving conditions where possible
- Encourage use of stormwater management practices within right-of-way limits

2.2.7 Government Policy
- Official Planning documents, Development Improvement Standards should reflect support for alternative stormwater protection measures
- Need for legislation which allows municipalities to recover costs for long term operation and maintenance (i.e. allow for provisions in Development Charges Act)
3 Conveyance Controls

Conveyance control measures are designed to treat stormwater runoff as it is conveyed from the source to the end-of-pipe (i.e. along roadways and in storm sewers). Conveyance controls are generally designed to promote natural infiltration and reduce downstream peak flows. It is important to note that typical infiltration methods may not be feasible within the Upper Blair subwatershed because of the potential to impair the quality of sensitive groundwater resources. Innovative design techniques, as described below, will need to be considered for road construction and reconstruction projects.

3.1 Grassed Swales
- typically associated with rural drainage
- used to filter and detain runoff
- enhances infiltration
- useful where space constraints exist

3.2 Pervious Pipes
- sewer system uses pervious pipe to promote exfiltration as runoff conveyed to local watercourse
- should be used in combination with pre-treatment to reduce high levels of sediment to maximize longevity of system

3.3 Pervious Catch Basins
- essentially standard catchbasins with deepened sumps which are physically connected to an exfiltration medium
- should be used in combination with pre-treatment to reduce high levels of sediment to maximize longevity of system

3.4 Swale and Perforated Pipe Infiltration System
The “Performance Assessment of a Swale and Perforated Pipe Stormwater Infiltration System” was recently carried out to assess the performance of an innovative swale and perforated pipe infiltration system that was constructed in a residential neighbourhood in the City of Toronto. The existing, ditched road network within the community was replaced with a grassed swale and underground infiltration trench with a standard roadside curb and gutter. The intent of the stormwater management system was to reduce runoff and peak flows, and to enhance the quality of stormwater runoff. Study findings included:
- average runoff reduction of 91 percent
- majority of rainfall events less than 5.5 mm produced negligible runoff due to storage and infiltration components within the system
- observed reduction in flow was primary factor in achieving 70 percent load-based removal efficiencies for several key water quality parameters

3.5 Filter / Buffer Strips
- applicable for small drainage areas
- combination of flow spreaders and vegetation (natural or planted) to promote infiltration, filter pollutants, provide shade and reduce overland flow velocities
4 End-of-Pipe Controls

End-of-pipe stormwater management facilities receive stormwater runoff from conveyance systems and are designed to release the treated water to the receiving watercourse at a pre-defined rate of flow. Early stormwater management practices, prior to the 1980’s, were designed to provide water quantity control for a particular development area and generally consisted of large, dry ponds. Over the last 10 years, the focus of water management has shifted from being relatively site specific, to the adoption of an ecosystem approach. Along with this new approach came the need for evolving stormwater management measures which not only addressed the issue of flooding, but also water quality and erosion concerns. End-of-pipe controls should be used in conjunction with lot level and conveyance controls to reduce the total pond volume and, correspondingly, the total land area required.

4.1 Wet Ponds

- most common type of end-of-pipe facility in Ontario
- incorporates a permanent pool component and relies primarily on detention and dilution for water quality treatment
- less land intensive than wetland facilities
- can provide water quality, quantity, and erosion control

4.2 Constructed Wetlands

- incorporates a shallow permanent pool component and relies primarily on detention and vegetative uptake for water quality treatment
- can provide water quality, quantity, and erosion control
- requires greater area of land than wet pond

4.3 Hybrid Wet Pond / Wetland Systems

- combination wet pond / wetland
- includes a deep water component and a shallow water component – gains best attributes of both wet ponds and wetlands
- provides greater biological uptake and less thermal impact during summer months

4.4 Dry Ponds

- typically used for quantity control only (MOEE SWMPD Manual (2003) provides water quality sizing criteria up to Basic level of treatment only (formerly Level 3))
- uses less land area than wet ponds and wetlands
- no permanent pool component
- re-suspension of sediments is a concern

4.5 Infiltration Basins / Trenches

- should be implemented for small drainage areas (<5 ha)
- infiltration system is designed to treat multiple lots
- applicability limited to areas where soil percolation rates are in excess of 60 mm/hr (generally soils coarser than a loamy sand)
4.6 Greenway Infiltration Systems
- somewhat unconventional “end-of-pipe” treatment system in that greenways (Open Space valleys) are employed throughout the development thereby minimizing the concentration of treatment at an end point
- no permanent pool
- require pre-treatment to minimize potential for excess sedimentation and/or spills contamination
- applicability limited to areas where soil percolation rates are in excess of 60 mm/hr (generally soils coarser than a loamy sand)
- effective for quantity control in that area of treatment is large enough to ensure ponding depths do not present compaction problems

4.7 Filters
- typically used for quality control only (no practical application for erosion, quantity control)
- relatively new application in Southern Ontario but has proven effective in parts of the United States
- can be aboveground or underground
- should be implemented for small drainage areas (≤ 5 ha)
- surface and sand filters are most common
- perimeter sand filter are especially useful around parking lots (commercial, industrial, institutional applications)
- organic filters can be designed as either surface or sub-surface system and employ a layer of peat in addition to the sand in order to enhance the removal of nutrients and trace metals
- filters employing other media (such as iron filings) have also been used with some success
- bioretention filters are similar to conventional surface filters, but allow the integration of open space and landscaping areas within the facility

4.8 Oil/Grit Separation Units
- used to trap oil and/or sediments in detention chambers, usually below ground
- often used as spill controls and/or as pre-treatment devices or end-of-pipe – controls as part of a multi-component approach to providing water quality control - particularly well-suited to sites where space is a constraint and/or retrofit or infill development situations
- number of proprietary and non-proprietary systems on the market but most are based on gravity-based or centrifugal sedimentation for the grit, and phase separation for the oil
- water quality treatment only, no detention or infiltration capacity
- applicable to small drainage areas (<2 ha)
References


1. Prevention

Similar to the 3 R’s (Reduce-Reuse-Recycle) principle of solid waste management with which we have all become familiar in recent years, the optimal approach to provision of SWM within developing areas is considered to be that which minimizes alterations to the hydrologic cycle in the first place, or the adoption of a ‘prevention’-based approach (i.e. Reduce) as opposed to the standard, ‘treatment’-based approach. Maximization of this type of SWM technique is considered optimal in that it is expected to represent the least “risky” in terms of potential for failure and, quite likely, the least expensive means of minimizing impacts. To this end, the “technology scan” includes a number of non-structural, or pollution prevention, approaches to SWM that inherently reduce the negative impacts of development.

Perhaps the easiest and most effective means of mimicking pre-development hydrologic conditions would be to limit the extent of development thereby preventing or limiting the creation of a typical post-development hydrologic condition requiring management in the first place. This approach is effectively equivalent to that taken with the recommended implementation of maximum impervious cover limits (ICL’s) established through the Blair, Bechtel and Bauman Creek Subwatershed Plan (BBB SWP). As this approach offers many hydrologic benefits, it qualifies as a “Best Management Practice” of stormwater management and is, therefore, worth pursuing herein. The BBB SWP introduces the concept of ICL as follows: “Imperviousness is one of the few variables municipal authorities can plan for, quantify, manage, and control at each stage of the land development process. By controlling the amount of impervious area, municipal authorities are able to directly control the impacts of land development. At the same time, municipal subdivision / site plan codes should be flexible enough to allow developers to optimize densities at lower levels of imperviousness.” The practices outlined in this section are all capable of impacting the extent of post-development stormwater that is created. Varying degrees of flexibility will be required of the municipality and/or developer as some of the practices, though previously implemented in other jurisdictions, may not be considered ‘standard’.

<table>
<thead>
<tr>
<th>BMP</th>
<th>General Description</th>
<th>SWM Benefits</th>
<th>SWM Drawbacks</th>
<th>Applicability</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Promotion of High Density Development</td>
<td>High density development (e.g. apartment buildings) results in reduced road frontage and driveway requirements per capita, dedicated more area to Open Space</td>
<td>Reduction in impervious coverage leading to reduction in runoff peaks and volumes, increased infiltration through pervious areas. Associated reduction in SWM treatment requirements.</td>
<td>Suitable everywhere from a SWM perspective. Other aspects such as Developer / Municipal planning policies and/or the capacity of servicing may restrict excessive application.</td>
<td>Schueler, Tom, 1995</td>
</tr>
<tr>
<td>B</td>
<td>Reduced Road Widths</td>
<td>Application of the concept of ‘headwater streets’, or those that are ‘highest’ in the traffic system that have the highest loading, as opposed to the wider and more heavily traveled arterial roads and highways. ‘Headwater streets’ are designed to reflect the actual anticipated traffic volumes, as opposed to blanket application of a minimum design standard that may have been established for another constraint. Recent studies indicate that ‘headwater streets’ represent between 50 and 65% of the length of the entire road network, thereby offering substantial opportunity to reduce imperviousness (analysis shows reduction of 30-50% of road imperviousness achievable).</td>
<td>Reduction in impervious coverage leading to reduction in runoff peaks and volumes, increased infiltration through pervious areas. Associated reduction in SWM treatment requirements.</td>
<td>Requires the adoption of alternative development standards to be fully implemented within Municipal right-of-ways. Municipalities hesitant to adopt this approach historically citing maintenance and safety requirements (e.g. snow removal / emergency vehicle access). Private developments (e.g., condos) can readily adopt.</td>
<td>Schueler, Tom, 1995</td>
</tr>
<tr>
<td>C</td>
<td>Reduced House Setbacks</td>
<td>Reduction in minimum allowable house setback from road right-of-way leading to a reduction in required driveway length.</td>
<td>Reduction in impervious coverage leading to reduction in runoff peaks and volumes, increased infiltration through pervious areas. Associated reduction in SWM treatment requirements.</td>
<td>Requires the adoption of alternative development standards to be fully implemented Municipal right-of-ways. Private developments (e.g., condos) can readily adopt.</td>
<td>Schueler, Tom, 1995</td>
</tr>
<tr>
<td>D</td>
<td>Alternative Turn-Around Standards for Dead-Ends</td>
<td>Implementation of T-shaped or “hammerhead” type turnarounds, reducing minimum radii standards for circular bulbs, or mandating a vegetated bulb centre.</td>
<td>Reduction in impervious coverage leading to reduction in runoff peaks and volumes, increased infiltration through pervious areas. Associated reduction in SWM treatment requirements.</td>
<td>Requires the adoption of alternative development standards to be fully implemented within Municipal right-of-ways. Municipalities hesitant to adopt this approach historically citing maintenance and safety requirements (e.g. snow removal / emergency vehicle access). Private developments (e.g., condos) can readily adopt.</td>
<td>Schueler, Tom, 1995</td>
</tr>
</tbody>
</table>
2. Lot Level Control

Lot level controls are designed to treat surface runoff at the source, closest to where the rain actually falls to the ground. The control of stormwater at source is preferred in that the dispersed nature of the treatment system tends to mimic the behaviour of natural systems more closely than concentrating treatment in an end-of-pipe facility, for instance. Source controls are significant for reducing pollutant loads to local water bodies partially through their ability to promote the infiltration of water at the site, rather than having runoff leave the site, where sediments and other contaminants are normally picked up along the roadways and other conveyance routes. Source control measures can be structural or non-structural in character and may depend on soil characteristics, land use, size of individual lots, and municipal acceptance. Source control measures are particularly useful for their water quality benefit and ability to reduce downstream peak flows and should be recognized for their applicability in retrofit situations where other measures may be too land-intensive.

A significant challenge that should be considered when designing and implementing a stormwater management strategy incorporating lot level techniques and other source controls is that many of these initiatives will be implemented on lands held in private ownership. Consequently, maintenance and the long-term effectiveness of the system are contingent on the actions of the landowner. Landowner education is the key to ensuring that systems remain effective over time. The successful application of lot level landscape solutions requires the commitment of the municipality and the establishment of creative partnerships between the developers, municipality and landowner to realize consistent benefits over the long term. A study commissioned by the City of Toronto in 1999 concluded that municipalities should take a leadership role in showcasing innovative control measures and educating the public, and should encourage partnership and incentive programs where feasible (J.F. Sabourin & Associates, 1999).

While the implementation of any of the Lot-Level BMP measures presented below would represent a SWM benefit, it is recognized that the ability to quantify the impacts is difficult if not impossible in the vast majority of instances and, therefore. Furthermore, without the mandating and follow-up enforcement of many of these items, it is expected that the average homeowner

<table>
<thead>
<tr>
<th>Structural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2. BMP</strong></td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>B</td>
</tr>
<tr>
<td>C</td>
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<td>D</td>
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<td>E</td>
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<td>---</td>
</tr>
<tr>
<td><strong>F</strong></td>
</tr>
<tr>
<td><strong>Increases transpiration and evaporation rates as rainwater is captured by vegetation.</strong></td>
</tr>
<tr>
<td><strong>Infiltration enhanced as plants absorb rainwater. Water quality benefits -vegetation acts as a natural filter removing pollutants and absorbing nutrients. Water quantity control benefits as roofs store and slowly release runoff.</strong></td>
</tr>
<tr>
<td><strong>Typically implemented on industrial / commercial / institutional-type facilities where large, flat roofs cater to the technology.</strong></td>
</tr>
<tr>
<td><strong><a href="http://www.greenroofs.org/">http://www.greenroofs.org/</a></strong></td>
</tr>
<tr>
<td><strong><a href="http://www.greenroofs.com/">http://www.greenroofs.com/</a></strong></td>
</tr>
</tbody>
</table>
## 2. Lot Level Control (cont’d)

<table>
<thead>
<tr>
<th>Non-Structural</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BMP</strong></td>
</tr>
<tr>
<td><strong>M</strong> Lawn Aeration</td>
</tr>
<tr>
<td><strong>N</strong> Municipal By-laws</td>
</tr>
<tr>
<td><strong>O</strong> Road Maintenance / Street Sweeping Practices Litter and Animal Waste Collection</td>
</tr>
</tbody>
</table>
3. Conveyance Controls

Conveyance control measures are designed to treat stormwater runoff as it is conveyed from the source to the end-of-pipe (i.e. along roadways and in storm sewers). Conveyance controls are generally designed to promote natural infiltration and reduce downstream peak flows. It is important to note that typical infiltration methods may not be feasible within the Upper Blair subwatershed because of the potential to impair the quality of sensitive groundwater resources. Innovative design techniques, as described below, will need to be considered for road construction and reconstruction projects.

<table>
<thead>
<tr>
<th>BMP</th>
<th>General Description</th>
<th>SWM Benefits</th>
<th>SWM Drawbacks</th>
<th>Applicability</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grassed Swales</td>
<td>Often associated with the ditch component of a rural road cross-section, but there’s no inherent requirement for a link between the road right-of-way and the swale integration into the development design in another fashion can be achieved.</td>
<td>Reduces peak flows. Provides significant water quality benefits if designed properly. Promotes infiltration</td>
<td>Storm servicing costs through the elimination of sewers</td>
<td>Suitable everywhere from a SWM perspective. May require municipal development standard or by-law to ensure implementation in all new developments. Private developments (e.g., condos) can readily adopt.</td>
<td>Elfering, Jody Mary, November 2002 Kuo, Jan-Tai, et al., 1999 University of Wisconsin, 2000</td>
</tr>
<tr>
<td>Pervious Pipes</td>
<td>Perforated storm sewer in coarse granular trench that allows the exfiltration of water to the surrounding soils as it is conveyed downstream.</td>
<td>Reduces volume of flow to sewer system and reduces size requirements for end-of-pipe SWM facilities. Increased infiltration.</td>
<td>Runoff directed to groundwater system without ‘pre-treatment’ per se thought the filtering through native soils will remove virtually all but dissolved pollutants.</td>
<td>Suitable in soils with infiltration rate ≥ 15 mm/hr though there is no significant technical reason why implementation in tighter soils is not feasible. Municipal acceptance unclear at this time.</td>
<td>Toronto and Region Conservation Authority, June 2002</td>
</tr>
<tr>
<td>Pervious Catch Basins</td>
<td></td>
<td>Reduces volume of flow to sewer system and reduces size requirements for end-of-pipe SWM facilities Promotes infiltration.</td>
<td>Impossible to accurately quantify impact on post-development hydrologic characteristics.</td>
<td>Suitable everywhere from a SWM perspective. Private developments (e.g., condos) can readily adopt.</td>
<td>MOE, March 2003</td>
</tr>
<tr>
<td>Swale and Pervious Pipe Infiltration System (a.k.a. Etobicoke Exfiltration System)</td>
<td></td>
<td></td>
<td>Requires the adoption of alternative development standards to be fully implemented within Municipal right-of-ways. Private developments (e.g., condos) can readily adopt.</td>
<td>MOE, March 2003</td>
<td></td>
</tr>
<tr>
<td>Filter / Buffer Strips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MOE, March 2003 University of Wisconsin, 2000</td>
</tr>
</tbody>
</table>
### 4. End-of-Pipe Controls

End-of-pipe stormwater management facilities receive stormwater runoff from conveyance systems and are designed to release the treated water to the receiving watercourse at a pre-defined rate of flow. Early stormwater management practices, prior to the 1980’s, were designed to provide water quantity control for a particular development area and generally consisted of large, dry ponds. Over the last 10 years, the focus of water management has shifted from being relatively site specific, to the adoption of an ecosystem approach. Along with this new approach came the need for evolving stormwater management measures which not only addressed the issue of flooding, but also water quality and erosion concerns.

End-of-pipe controls should be used in conjunction with lot level and conveyance controls to reduce the total pond volume and, correspondingly, the total land area required.

<table>
<thead>
<tr>
<th>BMP</th>
<th>General Description</th>
<th>SWM Benefits</th>
<th>SWM Drawbacks</th>
<th>Applicability</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Ponds</td>
<td>Deep water pond (~1.5 m deep permanent pool) primarily utilizing dilution and detention for provision of water quality treatment. Active storage component (above permanent pool) and outlet controls provided for peak flow reduction.</td>
<td>Reduces peak flows. Provision of water quality treatment. Infiltration component can be incorporated into the design, though liner will be required in areas of permeable soils to maintain permanent pool. Long-term performance dependent only on proper maintenance, which has become essentially standardized.</td>
<td>Thermal impacts (heating) a concern though design measures can mitigate.</td>
<td>Suitable in all areas from a SWM perspective and as pre-treatment for end-of-pipe infiltration. Upstream drainage area of ≥5 ha generally required in order to maintain a permanent pool and provide sufficient extended detention for small events.</td>
<td>MOE, March 2003 University of Wisconsin, 2000</td>
</tr>
<tr>
<td>Constructed Wetlands</td>
<td>Shallow water facility (wetland areas ~0.3 m deep) primarily utilizing detention and vegetative approaches for provision of water quality treatment. Active storage component (above permanent pool) and outlet controls provided for peak flow reduction.</td>
<td>Reduces peak flows. Provision of water quality treatment. Infiltration component can be incorporated into the design, though liner will be required in areas of permeable soils to maintain permanent pool. Long-term performance dependent only on proper maintenance, which has become essentially standardized.</td>
<td>Thermal impacts (heating) a concern though design measures can mitigate. Can be more land intensive than a wet pond but similarity to adjacent, natural ecology may warrant a preference in this regard.</td>
<td>Suitable in all areas from a SWM perspective and as pre-treatment for end-of-pipe infiltration. Upstream drainage area of ≥5 ha generally required in order to maintain a permanent pool and provide sufficient extended detention for small events.</td>
<td>MOE, March 2003 University of Wisconsin, 2000</td>
</tr>
<tr>
<td>Hybrid Wet Pond / Wetland Systems</td>
<td>Wet pond and wetland components connected in series, thus combining the benefits of dilution, detention, and vegetative uptake as described above.</td>
<td>Reduces peak flows. Provision of water quality treatment. Infiltration component can be incorporated into the design, though liner will be required in areas of permeable soils to maintain permanent pool. Long-term performance dependent only on proper maintenance, which has become essentially standardized. Better all-season performance can be expected than either element as a stand-alone.</td>
<td>Thermal impacts (heating) a concern though design measures can mitigate. More land intensive than either a wet pond or wetland as a stand-alone but proper landscaping can create very attractive features.</td>
<td>Suitable in all areas from a SWM perspective and as pre-treatment for end-of-pipe infiltration. Upstream drainage area of ≥5 ha generally required in order to maintain a permanent pool and provide sufficient extended detention for small events.</td>
<td>MOE, March 2003</td>
</tr>
<tr>
<td>Dry Ponds</td>
<td>Deep ponding area with no permanent pool of water relying entirely on detention of flows for quality and peak flow quantity control. Entire facility is ‘active’ storage.</td>
<td>Reduces peak flows. Provision of water quality treatment. Infiltration component can readily be incorporated into the design. Long-term performance dependent only on proper maintenance, which has become essentially standardized.</td>
<td>Quality treatment benefits are limited given the tendency toward re-suspension of previously settled sediments.</td>
<td>Suitable in all areas from a SWM perspective though will be required to represent a component in a treatment train approach to provision of water quality treatment. Upstream drainage area of ≥5 ha generally required in order to provide sufficient extended detention for small events.</td>
<td>MOE, March 2003</td>
</tr>
</tbody>
</table>
4. **End-of-Pipe Controls (cont’d)**

<table>
<thead>
<tr>
<th>BMP</th>
<th>General Description</th>
<th>SWM Benefits</th>
<th>SWM Drawbacks</th>
<th>Applicability</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infiltration Basins</strong></td>
<td>Above ground pond systems constructed in highly pervious soils. Detained water infiltrates into the ground for recharge to the groundwater system or collection via perforated pipe system for conveyance to a downstream outlet.</td>
<td>Reduces peak flows. Provision of water quality treatment. Provision of infiltration (in the case of no perforated pipe collection / conveyance system.)</td>
<td>Relatively high historical failure rate attributed primarily to factors that can be overcome with proper design and construction considerations. Infiltration in winter season is severely compromised.</td>
<td>Suitable in all areas of suitable soils. Upstream drainage area of &lt; 5 ha to minimize potential for failure. Limiting upstream drainage areas will also require more facilities, providing enhanced distribution of infiltration thereby mimicking existing conditions more closely. May require pre-treatment depending on characteristics of contributing drainage area.</td>
<td>MOE, March 2003</td>
</tr>
<tr>
<td><strong>Greenway Infiltration Systems</strong></td>
<td>Multi-level treatment system (at-source, conveyance, and end-of-pipe) forming an integral component of a development plan, typically located between the rear lots of parallel streets sized to retain and infiltrate the vast amount or even all runoff from a contributing drainage area.</td>
<td>Significantly reduces or even eliminates all runoff. Maximizes infiltration. Inherently results in almost all components of the SWM system in a given development being located where public access for inspection and maintenance is readily available.</td>
<td>Generally require more land area, but dry characteristic of majority of facility offers passive recreation benefits within the same area and property value of lots adjacent to a landscaped feature are known to be significantly higher. Seasonal variability in infiltration capabilities is recognized, but active storage volumes provided means that winter precipitation can simply be retained until such time as it can infiltrate / evaporate.</td>
<td>Suitable in all areas of suitable soils. Upstream drainage area of &lt; 5 ha to minimize potential for failure. Limiting upstream drainage areas will also require more facilities, providing better distributed infiltration thereby mimicking existing conditions more closely. May require pre-treatment depending on characteristics of contributing drainage area.</td>
<td>Stantec Consulting, November 1999</td>
</tr>
<tr>
<td><strong>Filters</strong></td>
<td>At-surface or underground system in which stormwater is directed through a filtering media (sand, peat, etc.) prior to discharge to a receiving system.</td>
<td>Provision of water quality treatment.</td>
<td>Very susceptible to clogging, particularly within the construction period.</td>
<td>Generally intended for use in small drainage areas (&lt; 5 ha) and typically implemented within parking lot areas or commercial sites. Some measure of pre-treatment required.</td>
<td>MOE, March 2003</td>
</tr>
<tr>
<td><strong>Oil / Grit Separation Units</strong></td>
<td>Small volume detention chambers, typically located below ground, used to trap and retain sediments, oils, greases and other floatables.</td>
<td>Provision of water quality treatment.</td>
<td>Depending on the Study cited, reported results have been quite variable (ranging from excellent to very poor).</td>
<td>Typically used predominantly as spills control on small industrial / commercial sites. Use in retrofit and pre-treatment situations has grown significantly in recent years. Typically accepted only as a component in a BMP ‘treatment train’ on new applications.</td>
<td>MOE, March 2003</td>
</tr>
</tbody>
</table>
APPENDIX D

Groundwater and Surface Water Road Salt Impact Assessment Memo

Summary of Recent Road Salt Application Studies

Code of Practice for the Environmental Management of Road Salts, April 2004

Selected Product Literature for Alternative Road De-Icing Chemicals

Stantec Memo – Peer Review of Doon South Thermal Regime

Ecoplans Memo – Doon South Thermal Regime

Mass Balance Temperature Analysis
One of the primary parameters of concern, in terms of groundwater and surface water quality within the Upper Blair Creek Subwatershed, is the anticipated increase in chloride concentrations resulting from the additional road salt application associated with the development of new road systems. In an effort to quantify potential chloride impacts to Blair Creek, a mass balance spreadsheet analysis was completed for the East and West Study Areas (Table D1), using the following methodology and assumptions:

- The GAWSER hydrologic model was used to determine the water balance for each subcatchment, including groundwater recharge.

- The total length of roads was estimated at 21% of a developing catchment’s area. This value was determined through a review of numerous recent Draft Plans of Subdivision.

- The length of existing and anticipated primary roads was measured with New Dundee Road and future Strasburg Road representing the only such systems. The length of secondary and local roadways within developed subcatchments was calculated by assuming that 25% of the remaining roadway area (total road area less primary road area) would consist of secondary roadways, with the remaining 75% being local roadways. In subcatchments not proposed for development (i.e., Greenspace), existing secondary roadway lengths were measured.

- The analysis assumed that the total mass of road salt applied as equivalent to the results of the Region’s Salt Management studies, or 44 tonnes / 2-ln-km for primary roads, 20 tonnes / 2-ln-km for secondary roads, and 1 tonne / 2-ln-km for local roads. These loading rates were confirmed as realistic through discussions with City of Kitchener maintenance managers and correspond with rates applied in recent years.
Chloride was used for purposes of completing the impact assessment since it is generally conservative in nature in comparison to sodium.

Chloride loading to the groundwater system was estimated based on the detailed modeling work completed by Stantec (2004) for the Region. Based on regional scale mass balance modeling, it was assumed that 30% of all road salt applied would infiltrate within the shoulder areas adjacent to the roads and through receiving creek / SWM systems where runoff has the potential to infiltrate. In areas where the year-round infiltration of treated road runoff occurs, 100% of the applied chloride is assumed to reach the groundwater systems as a “worst case” scenario (Scenario 2).

The total mass of chloride infiltrated together with the total groundwater recharge for each subcatchment was used to determine the average chloride concentration in groundwater from each subcatchment.

The total chloride loading to Blair Creek from each subcatchment was determined by multiplying the mass of chloride in groundwater by the baseflow contribution to the creek from each subcatchment. The chloride concentration in baseflow to Blair Creek was determined at New Dundee Road and at Dickie Settlement Road.

In an effort to quantify potential chloride impacts to groundwater, the MOE Reasonable Use Concept (RUC) approach was adopted. Although the RUC was not strictly developed for this purpose, it does provide a framework for assessing impacts to groundwater and, in this case, is also protective of impacts to surface water. Given the Ontario Drinking Water Standard for chloride is 250 mg/L and an assumed background chloride concentration in groundwater of 15 mg/L (which is typical of the ambient chloride levels in groundwater from southern Ontario), the RUC suggests that the maximum concentration of chloride in groundwater should not exceed 133 mg/L. By maintaining a groundwater chloride concentration of 133 mg/L, or less, the RUC suggests that this level of impact would have no appreciable effect on adjacent properties that may rely on groundwater as a potable water source.

Table D1 presents the predicted concentration of chloride in groundwater. Under post development conditions, the average concentration of chloride in groundwater from the East Study Area is predicted to be 74 mg/L, compared with an average groundwater chloride concentration of 109 mg/L from the West Study Area. The average groundwater chloride concentration from the entire Study Area is estimated to be 93 mg/L, which does not exceed the MOE RUC of 133 mg/L.
In terms of impacts to Blair Creek surface water, the average concentration of chloride in groundwater providing baseflow to the creek upstream of New Dundee Road is expected to be 80 mg/L. It should be noted that a significant amount of baseflow (approx. 165 L/s) from Roseville Swamp occurs between New Dundee Road and Dickie Settlement Road. Assuming an average chloride concentration of 15 mg/L for the baseflow provided from Roseville Swamp, the chloride concentration in Blair Creek can be expected to be diluted down to 37 mg/L at Dickie Settlement Road under baseflow conditions.

I trust that this is suitable for your current requirements. Please do not hesitate to contact the undersigned with any questions or concerns.

STANTEC CONSULTING LTD.

Roger Freymond, P.Eng.
Project Manager - Environmental Management
roger.freymond@stantec.com
### TABLE D1 - MASS BALANCE CHLORIDE ANALYSIS

<table>
<thead>
<tr>
<th>Area Description</th>
<th>Road Level (g/m²)</th>
<th>Total Road Level (g/m²)</th>
<th>Chloride Mass Balance (g/m²)</th>
<th>Chloride Impact to Groundwater</th>
<th>Chloride Impact to Creek at New Dunral Rd</th>
<th>Chloride Impact to Creek at Mud Springs Rd</th>
<th>Chloride Impact to Creek at Kitchener Water Supply Applied Salt Rate (g/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drafting Area 1</td>
<td>98.1</td>
<td>8.9</td>
<td>8.9</td>
<td>32.3</td>
<td>165,165</td>
<td>96,165</td>
<td>96,165</td>
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<tr>
<td>Drafting Area 2</td>
<td>20.5</td>
<td>8.9</td>
<td>8.9</td>
<td>32.3</td>
<td>165,165</td>
<td>96,165</td>
<td>96,165</td>
</tr>
<tr>
<td>Drafting Area 3</td>
<td>35.7</td>
<td>8.9</td>
<td>8.9</td>
<td>32.3</td>
<td>165,165</td>
<td>96,165</td>
<td>96,165</td>
</tr>
<tr>
<td>Drafting Area 4</td>
<td>145</td>
<td>8.9</td>
<td>8.9</td>
<td>32.3</td>
<td>165,165</td>
<td>96,165</td>
<td>96,165</td>
</tr>
</tbody>
</table>

Notes:
1. Total road salt applied assumed a loading rate of 20 tones/km² for primary roads, 44 tones/km² for secondary roads, and 2 tones/km² for local roads.
2. Percent of Road Level that of primary roads in drafting area 1 was assumed to be 15%.
3. Percent of Road Level that of primary roads in drafting area 2 was assumed to be 15%.
4. Percent of Road Level that of primary roads in drafting area 3 was assumed to be 15%.
5. Percent of Road Level that of primary roads in drafting area 4 was assumed to be 15%.
6. Percent of Road Level that of secondary roads in drafting area 1 was assumed to be 15%.
7. Percent of Road Level that of secondary roads in drafting area 2 was assumed to be 15%.
8. Percent of Road Level that of secondary roads in drafting area 3 was assumed to be 15%.
9. Percent of Road Level that of secondary roads in drafting area 4 was assumed to be 15%.
10. Percent of Local Road that of primary roads in drafting area 1 was assumed to be 15%.
11. Percent of Local Road that of primary roads in drafting area 2 was assumed to be 15%.
12. Percent of Local Road that of primary roads in drafting area 3 was assumed to be 15%.
13. Percent of Local Road that of primary roads in drafting area 4 was assumed to be 15%.
14. Percent of Local Road that of secondary roads in drafting area 1 was assumed to be 15%.
15. Percent of Local Road that of secondary roads in drafting area 2 was assumed to be 15%.
16. Percent of Local Road that of secondary roads in drafting area 3 was assumed to be 15%.
17. Percent of Local Road that of secondary roads in drafting area 4 was assumed to be 15%.
18. Percent of Local Road that of local roads in drafting area 1 was assumed to be 15%.
19. Percent of Local Road that of local roads in drafting area 2 was assumed to be 15%.
20. Percent of Local Road that of local roads in drafting area 3 was assumed to be 15%.
21. Percent of Local Road that of local roads in drafting area 4 was assumed to be 15%.

Column Descriptions:
- A: From CWSNR hyporhobic model
- B: In model areas, road salt applied area assumed to be 25% of total catchment area (A) based on analysis of analysis of about 30% for local roads, to non-model areas (e.g. Grovesponds, primary and secondary roads are measured as a percent of total area)
- C: Length of primary roads is measured directly from maps, New Dunral Road and Bond Drafting Road represent area for primary roads.
- D: Area of Primary Roads is the product of measured length and assumed areal rate of application.
- E: Area of model area is assumed to represent 25% of total area (C) to the primary road area (D) and to the secondary road area (E) to the local road area (F).
- F: Primary road area assumed to represent 10% of total road area (C) to the local road area (F).
- G: No local roads are assumed in the above areas.
- H: These values are not repeatable area of Grovesponds Road.
- I: Primary road area assumed to be a repeatable area of Grovesponds Road.
- J: Primary road area assumed to be a repeatable area of Grovesponds Road.
- K: Primary road area assumed to be a repeatable area of Grovesponds Road.
- L: Primary road area assumed to be a repeatable area of Grovesponds Road.
- M: Primary road area assumed to be a repeatable area of Grovesponds Road.
- N: Primary road area assumed to be a repeatable area of Grovesponds Road.
- O: Primary road area assumed to be a repeatable area of Grovesponds Road.
- P: Primary road area assumed to be a repeatable area of Grovesponds Road.
- Q: Primary road area assumed to be a repeatable area of Grovesponds Road.
- R: Primary road area assumed to be a repeatable area of Grovesponds Road.
- S: Primary road area assumed to be a repeatable area of Grovesponds Road.
- T: Primary road area assumed to be a repeatable area of Grovesponds Road.
- U: Primary road area assumed to be a repeatable area of Grovesponds Road.
- V: Primary road area assumed to be a repeatable area of Grovesponds Road.
- W: Primary road area assumed to be a repeatable area of Grovesponds Road.
- X: Primary road area assumed to be a repeatable area of Grovesponds Road.
- Y: Primary road area assumed to be a repeatable area of Grovesponds Road.
- Z: Primary road area assumed to be a repeatable area of Grovesponds Road.
Summary of Recent Road Salt Application Studies

The following discussion is a summary of the recently completed “Road Salt Management and Chloride Reduction Study Phase 2: Evaluation of Chloride Reduction Options” study, completed by Stantec Consulting Ltd., March 2004. Presentation summary sheets for two additional, though closely related studies, are included immediately following this discussion.

The impact of road salting on the environment has been investigated by a number of Canadian and International agencies over the past decade. In 1997, as part of the Long Term Water Supply Strategy, the water quality in each of the Regional Municipality of Waterloo’s (RMOW) 122 groundwater supply wells was assessed. In six of the wells, or approximately 5% of the supply, chloride concentrations had exceeded the Ontario Drinking Water Standard (ODWS) of 250 mg/L. While only a few wells had chloride concentrations that exceeded the ODWS, of greater concern was the increasing trend of chloride and sodium concentrations at most of the wells, particularly in the urban cores. Alerted by elevated chloride concentrations at some of the urban well fields in 1997, the RMOW recognized that work was required to better evaluate the potential impacts of winter road salting on groundwater supplies.

OVERALL STUDY OBJECTIVES

The overall objective of the Study was to determine the preferred option for stabilizing or reducing the concentration of chloride in drinking water at the RMOW well fields that are close to or exceeding the ODWS for chloride. The overall study objective will be achieved through consideration of region-wide road salt reduction initiatives, evaluation of more aggressive chloride reduction options, including treatment, and long-term water quality monitoring. To satisfy the overall study objective, a cost-effective mass balance modeling approach was developed to predict sodium and chloride concentrations at the individual well fields using information from previously developed groundwater flow models for the well fields.

MASS BALANCE MODEL

The mass balance model (MBM) developed as part of this Study is a box model that integrates a database program and a GIS program through an easy to use model interface. The overlying assumption in the MBM is that the observed chloride concentration at a well represents the mass of road salt that infiltrates to the groundwater table that is diluted by the recharge available within the capture zone. Essentially, the MBM provides an advective transport model where dispersion, diffusion, and decay are not considered.
In the MBM, the chloride concentrations at a well field are determined by the integration of the chloride mass from each ground surface capture zone over time. Because the capture zone modeling does not provide discrete capture zones for each individual well, the MBM was calibrated to the chloride concentration measured at the reservoir for each well field, which represents an average well field concentration. The predicted chloride concentrations at each well field are dependent on the following model parameters:

- Well Field Capture Zones;
- Recharge;
- Background Chloride Concentration;
- Road Salt Application Rates; and,
- Road Salt / Chloride Infiltration Rates.

Recharge in the model was determined for each capture zone area based on an assigned recharge rate that was either determined from previous groundwater flow modeling, or estimated based on the volume of recharge required to balance pumping in the steady-state capture zone. Recharge in the model can be assigned a chloride concentration to account for background chloride in precipitation or other chloride sources in the model area. The background chloride concentration is used in the model partially as a calibration parameter.

The historical road salt application rates were determined based on data available from the various winter maintenance agencies, which extended back to the late-1980s. Using the road salt application rates, and the historical winter maintained road network, the chloride loading to the groundwater system was calculated by varying the percentage of chloride that infiltrates until a reasonable match to the observed concentrations at the well field was obtained.

**EVALUATION OF CHLORIDE REDUCTION OPTIONS**

As part of the study a number of potential options were identified in consultation with the agencies responsible for winter road maintenance in the RMOW. The following options were identified for consideration:

- Option 1: Do Nothing
- Option 2: Well Field Management (Dilute Salt Water)
- Option 3: 25% Road Salt Reduction
- Option 4: 100% Road Salt Elimination within Well Field Capture Zones
- Option 5: Treatment of Salt Water.
The various agencies within the RMOW have committed to reducing road salt use through the implementation of a region wide Winter Maintenance Program. The first step of this program has been the development of standardized Winter Maintenance Policies and Procedures. As part of the policies and procedures the various agencies will be implementing a variety of programs, which are anticipated to achieve a 25% reduction in the amount of road salt applied. These programs include increased driver education, improvement monitoring, use of pre-wetting, and reduced salt application rates. In the 25% reduction option the road salt application rate has been reduced by 25% over the capture zone area beginning in 2003.

CONCLUSIONS AND RECOMMENDATIONS

Based on the detailed assessment of impacts of winter road salting on the well fields, it was concluded that the preferred option to manage chloride concentrations in the RMOW is through a 25% reduction in road salt application rates within the well field capture zones. Wells that are particularly sensitive may need a further reduction in road salt use or the use of a de-icing substitute.

For the 25% reduction option, the amount of road salt applied within the capture zone was reduced by 25%, with the amount of chloride reaching the water table reduced based on the percentage chloride allowed to infiltrate in the calibrated models. The assumption in the model is that the amount of chloride available to infiltrate is 25% less, which may not be the case based on the high solubility and concentration of chloride observed adjacent to the road networks. Monitoring is required to confirm the impact of the 25% reduction in road salt application rates.

A monitoring program should be implemented to confirm road salt application rates, the total road salt applied within the well field capture zones, and to evaluate the impact of the reduction in road salt application rates. The monitoring program should build on existing data collected prior to the implementation of road salt reduction measures. Key components to be considered in the monitoring program including: modifications to winter maintenance procedures, road salt application rates and total annual salt applied, shallow groundwater chloride concentrations adjacent to representative primary and secondary roads, and groundwater chloride concentrations from well fields. As a minimum the road salt loading data should be evaluated annually to confirm the percentage reduction in road salt application rate.
INTRODUCTION

The Regional Municipality of Waterloo (RMOW), alerted by elevated chlorine concentrations at some of their urban wells in 1997, recognized that work was required to better evaluate the potential impacts of winter road salting on groundwater supplies. Before a decision could be made regarding the long-term management of key urban well fields, a technically defensible and cost-effective methodology needed to be developed to allow predictions of future chlorine concentrations, and the evaluation of road salt reduction measures. While three-dimensional (3-D) unstructured-grid solute transport modeling represents the most sophisticated method for simulating the migration of solutes in the subsurface, an alternative approach needed to be developed due to the cost, and difficulty in calibrating a 3-D solute transport model for each of the high priority well fields.

Using previously developed time related capture zones, a mass balance modeling approach was developed using a box model that integrates a database program with GIS mapping data through an easy to use model interface. The mass balance model was compared with solute transport modeling results for the Greenbrook Well Field, one of the four high priority well fields (Greenbrook, Wilfrid, Parkway, Middleton Streets) located in the core urban areas of the City of Kitchener, Waterloo and Cambridge, Ontario (Figure 1). This paper presents the results of the solute transport and mass balance modeling for the Greenbrook Well Field.

STUDY APPROACH

In the mass balance model, the chloride concentration at the well field is determined by the integration of the chloride mass from each ground surface capture zone over time (Figure 2). Because the capture zone modeling does not provide for discrete capture zones for each well, the mass balance model was calibrated to calibrate the mass balance model input parameters: ground surface capture times, recharge, background chloride concentrations, road salt application rates, and road salt discharge rates.

RESULTS

Figure 4 presents the simulated chloride concentrations for the Greenbrook Well Field based on the calibrated mass balance and solute transport. The mass balance model was calibrated to the measured concentrations by allowing 27% of the road salt applied to infiltrate to the water table. The mass balance model correlates well with the measured concentrations and suggests the chloride concentrations trend to flatten out between 2000 and 2010, then increase again at a rate slightly less than the pre-2000 trend. The reason for this flattening trend is attributed to the "winterization" development of the winter-maintained road network. By 2041 chloride concentrations are predicted to reach 241 mg/L, and do not appear to be in steady-state.

CONCLUSIONS

The calibrated mass balance model and solute transport provide similar results, confirming the mass balance model provides a technically defensible method for evaluating impacts due to winter road salting on groundwater supplies. Based on the modeling results, approximately 27% of total road salt applied infiltrates to the groundwater table and is captured by the production wells. This value is within the range estimated based on detailed unsaturated zone investigations at six sites within the Greenbrook Well Field.

The mass balance modeling indicates chloride concentrations at the Greenbrook Well Field will reach 241 mg/L by 2041. If a 25% reduction in road salt application rates can be achieved, chloride concentrations are predicted to decrease to 210 mg/L by 2041. Further reduction chloride concentrations within groundwater at the well field, continue elimination of road salt within the 5-year and 10-year capture zones would reduce chloride concentrations to 181 mg/L and 164 mg/L by 2041. The data indicate that at well fields where chloride concentrations are above the CODWS, more aggressive options, such as the complete elimination of road salting may need to be considered.
FIELD CHARACTERIZATION OF ROAD SALT IMPACTS ON GROUNDWATER RESOURCES IN AN URBAN SETTING: KITCHENER, ONTARIO

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ABSTRACT

The Regional Municipality of Waterloo (RMOW) has commissioned a comprehensive study to investigate impacts of salt and chloride on groundwater resources in the vicinity of the Guelph-Waterloo region. As a part of this study, eight monitoring wells were installed in the eastern portion of the Kitchener South end of the Coventry Road subarea. The results of this study provide valuable information for the development of water management plans, especially for groundwater contamination due to road salt use. Whereas chronic exposure to high levels of chloride can cause significant long-term effects to groundwater resources, impacts caused by salt application in the residential area are of concern because of the high variability of salt use. Results indicate that groundwater concentrations of chloride are not elevated compared to background levels of approximately 1.5 mg/l. The study also highlights the importance of proper management practices to minimize the potential impacts of salt and chloride on groundwater resources.

RESULTS AND DISCUSSIONS

Figure 1. Borehole Locations and Road Types

Figure 2. Secondary Urban Road

Figure 3. Secondary Urban Road

Figure 4. Primary Urban Road

Figure 5. Primary Rural Road

Figure 6. Cuts Soil Profiling

Figure 7. Groundwater Chloride Concentrations

CONCLUSION

This study has shown that soil and groundwater chloride concentrations vary under different urban settings. Laboratory methods are found for different road types. Generally, it has been used that chloride concentrations higher in primary urbanized areas than those of secondary road types. However, a single sodium chloride reaction that may be used to determine background concentrations is chlorides in the vadose zone and regional groundwater flow. The average concentration in the vadose groundwater is 2.79 mg/l. Chloride concentrations are determined as the mean values and average background chloride concentrations in the vadose zone.

OBJECTIVES

The main objective of this study is to map the seasonal and spatial distribution of salt and chloride in groundwater resources in the vicinity of the Guelph-Waterloo region. The study also aims to assess the impacts of salt and chloride on groundwater resources and to identify areas of concern for future monitoring.

ROAD TYPES

The roads are generally divided into primary and secondary roads, depending on their priority with regard to snow clearance, high traffic volume, and potential need for chloride application. The priority roads are categorized as primary roads, while the secondary roads are categorized as secondary roads.

METHODOLOGY

Eight boreholes were drilled using continuous cores at a depth of 25 m, and soil samples were collected and preserved for chloride analysis. The chloride concentrations were determined through potentiometric titration with sodium hydroxide. The results indicate that chloride concentrations are not elevated compared to background levels in the vadose zone.
FEDERAL LEGISLATION & REGULATORY NEWS

CODE OF PRACTICE FOR THE ENVIRONMENTAL MANAGEMENT OF ROAD SALTS

Following pre-publication and a public comment period, Environment Canada has issued the final Code of Practice for the Environmental Management of Road Salts (the "Code"), under section 54(1) of the Canadian Environmental Protection Act, 1999 (published in Part I of the Canada Gazette:


The Code applies to "organizations" which are defined to include public entities that use or are responsible for the use of road salts on public roads in Canada and companies that hold a concession or lease to manage a public road. Organizations that use more than 500 tonnes of road salts per year and organizations that have vulnerable areas in their territory that could potentially be impacted by road salts have one year to prepare a salt management plan containing best management practices to protect the environment from the negative impacts of road salts. Annexes to the Code provide guidance for the identification of environmental impact indicators (Annex A) and vulnerable areas (Annex B) as well as a suggested approach to monitoring and measuring progress in road salt use, the implementation of best management practices and the concentration of road salts in the environment (Annex C).

The relevant section of the Canada Gazette .pdf file linked above is provided on the following pages.
GOVERNMENT NOTICES

DEPARTMENT OF THE ENVIRONMENT

CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

Notice with respect to the Code of Practice for the Environmental Management of Road Salts

Whereas road salts are a substance on the Priority Substances List, a list compiled under the Canadian Environmental Protection Act, 1999;

Whereas the scientific assessment conducted on this substance has concluded that road salts that contain inorganic chloride salts with or without ferrocyanide salts enter the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological biodiversity or that constitute or may constitute a danger to the environment on which life depends;

Whereas on December 1, 2001, the Minister of the Environment and the Minister of Health published in the Canada Gazette, Part I, a statement under subsection 77(6) of that Act indicating their intention to recommend that road salts which contain inorganic chloride salts with or without ferrocyanide salts be added to Schedule 1 of that Act;

Whereas, pursuant to subsection 54(1) of that Act, the Minister of the Environment shall issue codes of practices respecting pollution prevention or specifying procedures, practices or release limits for environmental control relating to works, undertakings and activities during any phase of their development and operation;

Whereas, pursuant to subsection 91(1) of that Act, the Minister of the Environment published in the Canada Gazette, Part I, on September 20, 2003, a copy of the proposed Code of Practice for the Environmental Management of Road Salts, substantially in the annexed form, and persons were given an opportunity to file comments with respect to the proposed Code of Practice or to file a notice of objections requesting that a board of review be established and stating the reasons for the objection;

Whereas the Code of Practice for the Environmental Management of Road Salts is intended to fulfill the requirement enacted in section 92 of that Act, to make an instrument respecting preventive or control actions within 18 months after the publication of the proposed instrument under subsection 91(1);

Therefore, the Minister of the Environment hereby issues, pursuant to subsection 54(1) of that Act, the Code of Practice for the Environmental Management of Road Salts, in accordance with the schedule hereto.

DAVID ANDERSON
Minister of the Environment

EXPLANATORY NOTE

(This note is not part of the notice.)

This Code of Practice was developed by Environment Canada through a multi-stakeholder consultation process for road salts that contain inorganic chloride salts with or without ferrocyanide salts.

AVIS DU GOUVERNEMENT

MINISTÈRE DE L’ENVIRONNEMENT

LOI CANADIENNE SUR LA PROTECTION DE L’ENVIRONNEMENT (1999)

Avis concernant le Code de pratique pour la gestion environnementale des sels de voirie

Attends que la substance sels de voirie figure sur la Liste des substances d’intérêt prioritaire établie en vertu de la Loi canadienne sur la protection de l’environnement (1999);

Attends que l’évaluation scientifique de cette substance a permis de conclure que les sels de voirie qui contiennent des sels inorganiques de chlorure avec ou sans sels de ferrocyanure pénètrent dans l’environnement en une quantité ou en une concentration ou dans des conditions de nature à avoir, immédiatement ou à long terme, un effet nocif sur l’environnement ou sur la biodiversité biologique, ou de nature à mettre en danger l’environnement essentiel pour la vie;

Attends que le ministre de l’Environnement et le ministre de la Santé ont publié dans la Partie I de la Gazette du Canada, le 1er décembre 2001, une déclaration conformément au paragraphe 77(6) de cette loi indiquant leur intention de recommander que la substance sels de voirie qui contiennent des sels inorganiques de chlorure avec ou sans sels de ferrocyanure soit ajoutée à l’annexe 1 de cette loi;

Attends que, conformément au paragraphe 54(1) de cette loi, le ministre de l’Environnement établit des codes de pratique concernant la prévention de la pollution et précisant les procédures, les méthodes ou les limites de rejet relatives aux ouvrages, entreprises ou activités au cours des divers stades de leur réalisation ou exploitation;

Attends que, conformément au paragraphe 91(1) de cette loi, le ministre de l’Environnement a fait publier dans la Partie I de la Gazette du Canada, le 20 septembre 2003, le projet de code de pratique intitulé Code de pratique pour la gestion environnementale des sels de voirie, conformément à la substance au texte ci-après, et que les intéressés ont ainsi eu la possibilité de présenter leurs observations à cet égard ou un avis d’opposition motivé demandant la constitution d’une commission de révision;

Attends que le Code de pratique pour la gestion environnementale des sels de voirie vise à satisfaire à l’exigence prescrite à l’article 92 de cette loi, qui est de prendre un texte portant sur des mesures de prévention ou de contrôle dans les 18 mois suivant la date où son projet a été publié en application du paragraphe 91(1);

À ces causes, il plait au ministre de l’Environnement d’établir, en vertu du paragraphe 54(1) de cette loi, le Code de pratique pour la gestion environnementale des sels de voirie, conformément à l’annexe ci-après.

Le ministre de l’Environnement

DAVID ANDERSON

NOTE EXPLICATIVE

(Cette note ne fait pas partie de l’avis.)

Ce code de pratique a été élaboré par Environnement Canada par le biais d’un processus de consultation multilatérale pour les sels de voirie qui renferment des sels inorganiques de chlorure avec ou sans sels de ferrocyanure.
CODE OF PRACTICE FOR THE ENVIRONMENTAL MANAGEMENT OF ROAD SALTS

INTERPRETATION

1. The following definitions apply in this Code:

"organization" means

(a) any public entity that uses or that is responsible for the use of road salts on public roads in Canada; or

(b) any company that holds a concession or lease to manage a public road, unless the public entity from which the company holds that concession or lease has developed a salt management plan that the company agrees to implement.

"road salts" mean road salts that contain inorganic chloride salts with or without ferrocyanide salts.


"vulnerable area" means an area particularly sensitive to road salts where additional salt management measures may be necessary to mitigate the environmental effects of road salts in that area; vulnerable areas should be identified as per the guidance provided in Annex B of the Code.

2. Recommendations in this Code propose preventive or control actions aimed at the environmental management of road salts to protect the Canadian environment.

3. This Code does not replace nor supersede any laws or regulations adopted by federal, provincial, territorial or municipal authorities in relation to, among other things, environmental protection, road safety or use of road salts.

4. This Code is not the sole guidance available to users of road salts in Canada, and is intended to be used in conjunction with the Salt Management Guide and Syntheses of Best Practices developed by the Transportation Association of Canada and any federal, provincial, territorial or municipal maintenance standards. Nothing in this Code should be construed as a recommendation to take action to the detriment of road safety.

APPLICATION

5. This Code applies to

(a) organizations that use more than 500 tonnes of road salts per year (five-year rolling average); and

(b) organizations that have vulnerable areas in their territory that could be potentially impacted by road salts.

6. This Code does not apply to road salts used for domestic purposes, or for private or institutional uses.

SALT MANAGEMENT PLAN

7. An organization that meets the criteria of section 5 should prepare and implement a salt management plan that contains best

CODE DE PRATIQUE POUR LA GESTION ENVIRONNEMENTALE DES SELS DE VoirIE

DÉFINITIONS

1. Les définitions qui suivent s'appliquent au présent code :

« organisation » Selon le cas :

a) toute entité publique qui utilise des sels de voirie ou qui est responsable de leur utilisation sur les routes publiques au Canada;

b) toute compagnie qui détient une concession ou un bail permettant de gérer une route publique, à moins que l'entité publique de laquelle elle détient cette concession ou ce bail n'ait développé un plan de gestion des sels de voirie que la compagnie accepte d'exécuter.

« sels de voirie » Sels de voirie qui contiennent des sels inorganiques de chlore avec ou sans sels de ferrocyanure.


« zone vulnérable » Zone particulièrement sensible aux sels de voirie où des mesures supplémentaires de gestion des sels de voirie peuvent s'avérer nécessaires pour atténuer les effets des sels de voirie sur l'environnement dans cette zone; les zones vulnérables devraient être identifiées en fonction des conseils fournis dans l'annexe B du Code.

2. Les recommandations formulées dans ce code proposent des mesures de prévention et de contrôle pour la gestion environnementale des sels de voirie de façon à protéger l'environnement canadien.

3. Le présent code ne remplace aucune des lois ni aucun des règlements concernant entre autres la protection de l'environnement, la sécurité routière ou l'utilisation des sels de voirie, adoptés par le gouvernement fédéral, les provinces, les territoires ou les municipalités, ni n'a préséance sur ces lois et règlements.

4. Le présent code n'est pas la seule source de conseils disponible pour les utilisateurs de sels de voirie au Canada. Il est destiné à être utilisé conjointement avec le Guide de gestion des sels de voirie et les Synthèses des meilleures pratiques élaborés par l'Association des transports du Canada (ATC), ainsi qu'avec toute norme d'entretien fédérale, provinciale, territoriale ou municipale existante. Aucune des dispositions du présent code ne devrait être interprétée comme une recommandation pour agir au détriment de la sécurité routière.

CHAMP D'APPLICATION

5. Ce code s'applique :

a) aux organisations qui utilisent plus de 500 tonnes de sels de voirie par année (moyenne mobile de cinq ans);

b) aux organisations qui comptent sur leur territoire des zones vulnérables qui pourraient être affectées par les sels de voirie.

6. Le présent code ne s'applique pas aux utilisations des sels de voirie à des fins domestiques, ou aux utilisations privées ou institutionnelles.

PLAN DE GESTION DES SELS DE VoirIE

7. Une organisation qui répond aux critères mentionnés à l'article 5 devrait préparer et mettre en œuvre un plan de gestion
management practices to protect the environment from the negative impacts of road salts. The management plan should cover all activities which may result in the release of road salts to the environment, such as salt storage, application of salts on roads, and disposal of snow containing road salts.

8. An organization that does not meet the criteria of section 5 should consider implementing the best management practices that are relevant to its local conditions in order to protect the environment from the negative impacts of road salts.

9. The salt management plan should
   (a) provide a statement recognizing the role of a salt management plan in achieving improved environmental protection without compromising road safety;
   (b) provide a commitment or endorsement of the plan at the highest level in the organization;
   (c) identify activities or operations through which road salts may be released to the environment and goals to achieve reduction of the negative environmental impacts of these releases;
   (d) assess current practices against recommended best management practices, including those contained in the TAC Syntheses of Best Practices;
   (e) contain documentation of all policies and procedures applicable to the salt management plan;
   (f) include communication activities necessary to inform the organization and the public of the salt management plan and related policies and procedures;
   (g) contain a training program for all personnel when managing or performing winter maintenance activities involving the use of road salts;
   (h) provide response procedures to react to uncontrolled releases of road salts that could result in environmental impacts;
   (i) ensure monitoring of actions to measure the plan’s effectiveness;
   (j) include record-keeping as described in section 15 of this Code;
   (k) include a procedure for yearly review of the plan by the organization with continual improvement of salt management practices and the salt management plan as better management practices become known and progress is achieved; and
   (l) establish and implement corrective actions to address deficiencies identified in the operations of the organization to which the plan applies.

10. The environmental impact indicators listed in Annex A, the guidance for identifying vulnerable areas provided in Annex B and the data gathering and reporting provisions in Annex C of this Code should be considered during the development and implementation of the salt management plan.

11. The content and level of detail of the salt management plan may vary according to the organization’s size and capability.

des sels de voirie contenant les meilleures pratiques de gestion pour assurer la protection de l’environnement contre les impacts négatifs des sels de voirie. Le plan de gestion devrait couvrir toutes les activités qui peuvent entraîner un rejet de sels de voirie dans l’environnement, telles que l’entreposage et l’épandage des sels ainsi que l’élimination de la neige contaminée par des sels de voirie.

8. Une organisation qui ne répond pas aux critères mentionnés à l’article 5 devrait envisager de mettre en œuvre des mesures de gestion des sels de voirie et d’adopter les meilleures pratiques de gestion applicables selon ses conditions locales pour assurer la protection de l’environnement contre les impacts négatifs des sels de voirie.

9. Le plan de gestion des sels de voirie devrait :
   a) comprendre un énoncé reconnaissant le rôle d’un plan de gestion des sels de voirie pour assurer une meilleure protection de l’environnement sans compromettre la sécurité routière;
   b) comprendre un engagement de la haute direction de l’organisation envers le plan ou un endossement de celui-ci;
   c) déterminer les activités ou opérations par lesquelles les sels de voirie peuvent être rejetés dans l’environnement ainsi que les objectifs à fixer pour parvenir à réduire les impacts négatifs sur l’environnement qui en découlent;
   d) évaluer les pratiques courantes par rapport aux meilleures pratiques de gestion recommandées, comprenant celles qui sont contenues dans les Synthèses des meilleures pratiques de l’ATC;
   e) documenter toutes les politiques et les procédures qui s’appliquent au plan de gestion des sels de voirie;
   f) inclure les activités de communication requises pour informer l’ensemble de l’organisation et le public du plan de gestion des sels ainsi que des politiques et procédures connexes;
   g) contenir un programme de formation s’adressant à tous les membres du personnel qui gèrent ou exécutent des activités d’entretien hivernal des routes impliquant l’utilisation de sels de voirie;
   h) comprendre des procédures d’intervention à appliquer en cas de rejets accidentels de sels de voirie pouvant avoir un impact négatif sur l’environnement;
   i) assurer un suivi des mesures prises en vue d’évaluer l’efficacité du plan de gestion;
   j) inclure une tenue de dossiers telle qu’elle est décrite à l’article 15 du présent code;
   k) inclure un processus d’examen annuel du plan par l’organisation avec amélioration continue des pratiques et du plan de gestion des sels de voirie à mesure que de meilleures pratiques sont connues et que des progrès sont accomplis;
   l) établir et mettre en œuvre des mesures correctrices pour corriger les lacunes relevées dans les opérations de l’organisation auxquelles le plan s’applique.


11. Le contenu et le niveau de détails du plan de gestion des sels de voirie peuvent varier selon la taille et les capacités de l’organisation.
BEST MANAGEMENT PRACTICES

12. It is recommended that best management practices referred to in sections 7 and 8 and found in the TAC Syntheses of Best Practices be selected according to the following objectives:

(a) Salt Storage: The objective is the prevention or control of releases from existing and new sites. In pursuing this objective, the following practices should be considered: coverage of salt piles and blended salt-sand piles, handling practices that avoid uncontrolled releases, drainage management, wash water collection and treatment, training of personnel, and monitoring of the effectiveness of the facility.

(b) Snow Disposal: The objective is the control of releases from existing and new sites. In pursuing this objective, the following practices should be considered: location and construction of the sites to take into account operational and environmental factors, drainage management, training of personnel and monitoring of the effectiveness of the facility.

(c) Salt Application: The objective is the reduction of the negative impacts of road salts by delivering the right amount of road salts in the right place at the right time. In pursuing this objective, consideration should be given to using the most recent advancements in the application of winter maintenance anti-icing and de-icing materials, winter maintenance equipment, and road weather information and other decision support systems. As well, the training of personnel and the monitoring of the effectiveness of road salt application techniques should be considered.

IMPLEMENTATION

13. An organization that meets the criteria of section 5 should prepare a salt management plan within one year after publication of this Code in the Canada Gazette. It is recommended that implementation of the plan begins in the financial period or fiscal year immediately following the preparation of the plan.

14. It is recommended that organizations hiring agents or contractors ensure that those agents or contractors comply with any measures in the salt management plan related to their work.

RECORD-KEEPING AND REPORTING

15. An organization that meets the criteria of section 5 should

(a) provide to the Minister of the Environment
(i) notification of intent to prepare a salt management plan within six months after publication of this Code in the Canada Gazette or within six months of becoming subject to this Code, whichever is later; and
(ii) information specified in Annex C of this Code, in the form provided by the Minister, by June 30 of the year following the year that the organization becomes subject to this Code and every year thereafter;

(b) keep records of all data reported, copies of the salt management plan, plan revisions, training records, and any yearly review reports, including those that contain corrective action;

MEILLEURES PRATIQUES DE GESTION

12. Il est recommandé que les meilleures pratiques de gestion mentionnées aux articles 7 et 8 et qu’on retrouve dans les Synthèses des meilleures pratiques de l’ATC, soient sélectionnées en fonction des objectifs ci-après :

a) Entreposage des sels : L’objectif est la prévention ou le contrôle des rejets provenant des sites nouveaux et existants. Afin d’atteindre cet objectif, les pratiques suivantes devraient être envisagées : recouvrement des piles de sels et de mélanges de sable et de sels, pratiques de manipulation qui évitent les rejets non contrôlés, gestion du drainage, collecte et traitement des eaux de lavage, formation du personnel et surveillance de l’efficacité des installations.

b) Élimination de la neige : L’objectif est le contrôle des rejets provenant des sites nouveaux et existants. Afin d’atteindre cet objectif, les pratiques suivantes devraient être envisagées : emplacement et construction des sites pour prendre en compte les facteurs opérationnels et environnementaux, gestion du drainage, formation du personnel et surveillance de l’efficacité des installations.

c) Épandage des sels de voirie : L’objectif est la réduction des impacts négatifs des sels de voirie en appliquant les bonnes quantités de sels aux bons endroits et au bon moment. Pour atteindre cet objectif, on devrait envisager l’utilisation des plus récents progrès dans l’application des produits de dégelage et d’antiglissage pour l’entretien hivernal, l’équipement d’entretien hivernal, et les systèmes d’informations météorologiques pour les routes et autres systèmes d’aide à la décision. De plus, la formation du personnel et la surveillance de l’efficacité des techniques d’application de sels de voirie devraient être envisagées.

MISE EN ŒUVRE

13. Une organisation qui répond aux critères mentionnés à l’article 5 devrait élaborer un plan de gestion des sels de voirie dans l’année suivant la publication du présent code dans la Gazette du Canada. Il est recommandé que la mise en œuvre du plan débute dans la période comptable ou l’exercice financier qui suit immédiatement l’élaboration du plan.

14. Il est recommandé que les organisations qui engagent des agents ou entrepreneurs s’assurent que ceux-ci se conforment à toutes les mesures du plan de gestion des sels de voirie qui ont trait à leur travail.

TENUE DE DOSSIERS ET PRODUCTION DE RAPPORTS

15. Une organisation qui répond aux critères mentionnés à l’article 5 devrait :

a) fournir au ministre de l’Environnement
(i) un avis indiquant son intention de préparer un plan de gestion des sels de voirie dans les six mois suivant la publication du présent code dans la Gazette du Canada ou dans les six mois suivant la date à laquelle elle devient visée par le présent code, selon celui de ces moments qui est postérieur à l’autre;
(ii) l’information précisée dans l’annexe C du présent code, sous la forme fournie par le ministre, au plus tard le 30 juin de l’année suivant l’année pendant laquelle l’organisation devient visée par le présent code, et chaque année par la suite;
(c) retain the information referred to in paragraph (b) for seven years; and
(d) make the information referred to in paragraph (b) available to the Minister of the Environment upon request.

16. In order to monitor the effectiveness of this Code, organizations will be invited to cooperate with the Minister of the Environment in the preparation of progress reports on the development and implementation of salt management plans.

17. (a) Five years after publication of this Code in the Canada Gazette, organizations will be invited to cooperate with the Minister of the Environment and to participate in an evaluation of progress achieved towards prevention and reduction of the negative impacts of road salts on the environment through the implementation of this Code.
(b) The review will consider the level of implementation of best management practices, such as those found in the TAC Syntheses of Best Practices, the progress accomplished towards preventing or reducing the negative impacts of road salts on the Canadian environment and road safety monitoring data.
(c) This review will help determine if other steps or programs are needed to further prevent or reduce negative impacts of road salts on the environment.

Annex A: Environmental Impact Indicators for Road Salts

Introduction
The purpose of Annex A is to provide guidance by identifying concentrations of chloride in the environment at which certain negative environmental impacts are likely to occur. A series of thresholds have been identified for different environmental compartments: surface water, groundwater and soil. Concentrations above these levels have the potential to result in negative impacts. In all cases, natural background concentrations should be considered in evaluating regional and local impacts. Data in this annex are based on findings presented in the Road Salts Priority Substances List Assessment Report.

Surface water
The following paragraphs present certain thresholds associated with concentrations of chloride in surface water.

Figure 1 presents background concentrations of chloride in Canadian surface waters and concentrations of chloride that cause adverse biological effects. The column on the left provides a range of average background concentrations for five regions in Canada. The variation in background concentrations of chloride is greatest in western Canada and markedly decreases moving

Annexe A: Indicateurs d'impact environnemental pour les sels de voirie

Introduction
L'annexe A a pour objet de fournir des conseils par la détermination des concentrations de chlore dans l'environnement auxquelles certains impacts négatifs environnementaux sont susceptibles de se produire. On y définit une série de seuils pour divers milieux environnementaux: eaux de surface, eaux souterraines et sol. Les concentrations au-dessus de ces seuils ont le potentiel de produire des impacts négatifs. Dans tous les cas, on devrait tenir compte des concentrations naturelles au moment d’évaluer les impacts régionaux et locaux. Les données présentées dans cette annexe sont basées sur les conclusions du Rapport d’évaluation de la Liste des substances d’intérêt prioritaire pour les sels de voirie.

Eaux de surface
Les paragraphes qui suivent définissent certains seuils associés aux concentrations de chlore mesurées dans les eaux de surface. La figure 1 indique les concentrations naturelles de chlore mesurées dans des eaux de surface du Canada et les concentrations qui causent des effets biologiques nocifs. Ainsi, la colonne de gauche indique la fourchette des concentrations naturelles moyennes pour cinq régions du Canada. L’écart des concentrations est plus grand dans l'Ouest canadien et il diminue de façon
eastward to the Great Lakes area and Atlantic Canada. The lowest variation in chloride concentration is reported on the Canadian Shield.

The right column of Figure 1 is useful for identifying the levels of chloride in surface waters above and below concentrations reported to cause certain negative impacts. Concentrations of chloride of approximately 140 mg/L should be protective of freshwater organisms for short-term exposure; concentrations less than 35 mg/L are likely protective during long-term exposures. Overall, approximately 5 percent of species are predicted to experience effects from chronic exposure to concentrations of chloride of about 210 mg/L, while 10 percent of species would be affected at concentrations of about 240 mg/L.

Other jurisdictions have derived guidelines for the exposure of aquatic organisms to chlorides (Fig. 1). The United States Environmental Protection Agency (EPA) developed a similar guideline. Overall, the EPA guideline indicates that biota, on average, should not be affected unacceptably if the four-day average concentration of chloride does not exceed 230 mg/L more than once every three years. Similarly, the biotic impacts would be minimal if the one-hour average chloride concentration does not exceed 860 mg/L more than once every three years.

Lakes located in Canada typically undergo vertical mixing every spring and fall as a result of a change in water temperature. Dissolved salts can hinder the vertical mixing of water bodies as dense, salt-laden water sinks to deeper layers (meromixis). The absence of vertical mixing can ultimately lead to a depletion of oxygen in the lower layers of lakes and a reduction in the cycling of nutrients. Meromictic conditions have developed in lakes with salt concentrations of approximately 60 mg Na/L and 105 mg Cl/L. Small, deep lakes are the most vulnerable, although concentrations associated with meromixis will vary greatly, depending on local conditions.

Groundwater

Chloride concentrations identified for freshwater biota will likely be protective of groundwater biota and groundwater that emerges into surface water.

A significant proportion of road salts may be contained within the groundwater system. The time taken to reach an equilibrium where salt inputs are balanced by salt outputs depends on local hydrogeological conditions and may take from a few years to hundreds of years.

Soils

Soil integrity, soil organisms and vegetation will generally be protected at concentrations of about 60 mg Na/L and 90 mg Cl/L. Damage to plants has also been observed at soil concentrations of 16 mg Na/kg and 30 mg Cl/kg (dry weight). Changes in natural plant communities have been recorded in areas affected by road salts runoff and liquid salt spray from moving vehicles.

marquée à mesure que l'on se dirige vers l'est des Grands Lacs et vers le Canada atlantique. C'est dans le Bouclier canadien que l'on a signalé l'écart le plus faible de concentrations de chlorure.

La colonne de droite de la figure 1 est utile pour déterminer les niveaux auxquels certains effets négatifs se manifestent. Une concentration de chlorure d'environ 140 mg/L devrait avoir un effet protecteur sur les organismes dulcicoles lors d'expositions à court terme, et une concentration inférieure à 35 mg/L aura probablement un effet protecteur lors d'expositions à long terme. Dans l'ensemble, on prévoit qu'environ 5 p. 100 des espèces subiront des effets résultant d'une exposition chronique à une concentration de chlorure d'environ 210 mg/L et que 10 p. 100 seraient touchées à une concentration d'environ 240 mg/L.

D'autres compétences ont établi des lignes directrices sur l'exposition des organismes aquatiques aux chlorures (fig. 1). L'Environmental Protection Agency (EPA) des États-Unis a élaboré des lignes directrices similaires. De façon générale, les lignes directrices de l'EPA indiquent que le biote ne devrait pas être touché de façon inacceptable si la concentration moyenne de chlorure sur quatre jours ne dépasse pas 230 mg/L plus d'une fois en moyenne tous les trois ans, et si la concentration binaire moyenne n'excède pas 860 mg/L plus d'une fois en moyenne tous les trois ans.

Tous les printemps et tous les autumnes, il se produit habituellement un mélange vertical des eaux dans les lacs du Canada, sous l'effet des variations de la température de l'eau. Les sels dissous peuvent perturber le mélange vertical dans les plans d'eau, car les eaux denses et chargées de sels descendent vers les couches plus profondes (méromicticité). L'absence de mélange vertical peut entraîner à la longue une raréfaction de l'oxygène dans les couches inférieures du lac et une réduction du cycle des éléments nutritifs. Des conditions méromictiques ont ainsi été observées dans des lacs où la concentration de sodium était d'environ 60 mg/L et celle de chlorure, d'environ 105 mg/L. Ce sont les lacs petits et profonds qui sont les plus vulnérables, bien que les concentrations causant une méromicticité varient considérablement en fonction des conditions locales.

Eaux souterraines

Les concentrations de chlorure indiquées pour le biote dulci- cole auront probablement un effet protecteur sur le biote des eaux souterraines, et sur les eaux souterraines qui se mêlent aux eaux de surface.

Une proportion appréciable des sels de voirie peuvent se retrouver dans le réseau des eaux souterraines. Le temps nécessaire pour parvenir à un équilibre entre l’apport de sels et leur retrait dépend des conditions hydrogéologiques locales et peut varier de quelques années à des centaines d’années.

Sol

De façon générale, l’intégrité des sols, la pédofaune et la végétation seront protégées à des concentrations d’environ 60 mg de Na/L et 90 mg de Cl/L. Cependant, des dommages à la végétation se sont produits à des concentrations de 16 mg de Na/kg et de 30 mg de Cl/kg (en poids sec), dans le sol. De même, des changements dans la phytocénose naturelle ont été observés dans des régions touchées par des sels de voirie entraînés sous l’effet du ruissellement ou des éclaboussures provenant de la circulation ruheit.
Figure 1. Comparison of natural background concentrations of chloride in Canadian surface water and thresholds for adverse biological effects. The column on the left provides an overview of average background concentrations for five regions in Canada. The column on the right identifies levels at which certain impacts may occur. Data in this figure helps characterize average background concentrations for different areas and impacts that can occur at different concentrations.

**Chloride Concentrations, mg/L**

<table>
<thead>
<tr>
<th>Natural Background Concentrations</th>
<th>Effects Concentrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 000 mg/L</td>
<td>10 000 mg/L</td>
</tr>
<tr>
<td>1 000 mg/L</td>
<td>1 000 mg/L</td>
</tr>
<tr>
<td>100 mg/L</td>
<td>100 mg/L</td>
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<tr>
<td>10 mg/L</td>
<td>10 mg/L</td>
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<tr>
<td>1 mg/L</td>
<td>1 mg/L</td>
</tr>
</tbody>
</table>

- British Columbia (Mayer et al., 1999)
- Prairies (Mayer et al., 1999)
- Canadian Shield (Mayer et al., 1999)
- St. Lawrence Lowlands and Great Lakes (Mayer et al., 1999)
- Atlantic Canada (Mayer et al., 1999)
- Species should not be negatively affected if one-hour average concentration of Cl does not exceed value more than once every three years. (U.S. EPA 1988)
- Species should not be negatively affected if 4-day average concentration of Cl does not exceed value more than once every three years. (U.S. EPA 1988)
- Based on predicted data, 5% of species would be negatively affected (median lethal concentration). [Evans and Frick, 2001]
- Based on predicted data, 10% of species would be negatively affected (median lethal concentration). [Evans and Frick, 2001]
- Estimated no effects value derived from Ceriodaphnia dubia 4-day LC50 (Cowgill and Milazzo, 1990)
- Estimated no effects value derived from 33-day LOEC survival for fathead minnow (Birge et al., 1985)
- Chloride concentration in lower layers of water body associated with meromixis (Snol et al., 1985)
- To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of total chloride at any time should not exceed this value. *(BC Ambient Water Quality Guidelines for Chloride, 2002)*
- To protect freshwater aquatic life from chronic effects, the 30-day average concentration of total chloride should not exceed this value. *(BC Ambient Quality Guidelines for Chloride, 2002)*
Figure 1. Comparaison entre les concentrations naturelles de chlorure dans les eaux de surface canadiennes et les seuils causant des effets biologiques nocifs. La colonne de gauche présente un aperçu des concentrations naturelles moyennes dans cinq régions du Canada, tandis que la colonne de droite indique les niveaux auxquels certains effets pourraient se produire. Ces données aident à déterminer les concentrations naturelles moyennes dans différentes régions, ainsi que les effets susceptibles de se produire à différentes concentrations.

<table>
<thead>
<tr>
<th>Concentrations de chlorure (mg/L)</th>
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<tbody>
<tr>
<td>Concentrations naturelles</td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td>10 000</td>
</tr>
<tr>
<td>1 000</td>
</tr>
<tr>
<td>mg/L</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

- **13-140**
- **<5-100**
- **10-30**
- **1-5**
- **<10-20**
- **<35**
- **210**
- **230**
- **240**
- **103,7**
- **860**
- **600**

* Colombie-Britannique (Mayer et al., 1999)
* Prairies (Mayer et al., 1999)
* Bouclier canadien (Mayer et al., 1999)
* Basses-terres du Saint-Laurent et Grands Lacs (Mayer et al., 1999)
* Canada atlantique (Mayer et al., 1999)

Les espèces ne devraient pas être touchées négativement si la concentration horaire moyenne de Cl ne dépasse pas cette valeur plus d’une fois tous les trois ans. (U.S. EPA, 1988)

Les espèces ne devraient pas être touchées négativement si la concentration moyenne de Cl sur quatre jours ne dépasse pas cette valeur plus d’une fois tous les trois ans. (U.S. EPA, 1988)

D’après les prévisions, 5 % des espèces seraient touchées négativement (concentration létale moyenne).

[Evans et Frick, 2001]

D’après les prévisions, 10 % des espèces seraient touchées négativement (concentration létale moyenne).

[Evans et Frick, 2001]

Niveau sans effet, estimé d’après la valeur de la CL50 sur 4 jours pour Ceriodaphnia dubia (Cowgill et Milazzo, 1990)

Niveau sans effet, estimé d’après la CMEO sur 33 jours pour la tête-de-boule (Birge et al., 1985)

Concentration de chlorure dans les couches inférieures d’un plan d’eau méromictique (Smol et al., 1985)

Afin d’éviter la manifestation d’effets aigus et létaux chez les organismes dulcicoles, la concentration maximale de chlorure total ne devrait jamais dépasser cette valeur. (*BC Ambient Water Quality Guidelines for Chloride, 2002*)

Afin d’éviter la manifestation d’effets chroniques chez les organismes dulcicoles, la concentration moyenne de chlorure total sur 30 jours ne devrait pas dépasser cette valeur. (*BC Ambient Quality Guidelines for Chloride, 2002*)
Annex B: Guidance for Identifying Areas That Are Vulnerable to Road Salts

Purpose

The purpose of Annex B is to provide guidance for organizations to consider when identifying areas of a receiving environment that may be particularly sensitive to road salts. Once a vulnerable area has been identified, organizations may then determine the level of vulnerability and the need to implement additional salt management measures.

Additional salt management measures in vulnerable areas may include:
- using technologies that further optimize the use of road salts;
- using environmentally, technically and economically feasible alternatives to road salts;
- increasing monitoring and measuring of chlorides and/or their impacts;
- locating patrol yards and snow disposal sites outside of vulnerable areas; or
- considering location and protection of vulnerable areas in the design of new roads and/or upgrading of existing roads.

It is important to note, when identifying vulnerable areas, that an area may be vulnerable either to infrequent but heavy addition of road salts or to light but frequent addition of road salts.

Organizations may consider consulting with entities that conduct, under their programs, work that could be relevant to the identification of areas vulnerable to road salts. In addition, organizations may wish to exchange information with other organizations adjacent to or having common authority over these vulnerable areas and consult with their constituents.

Notes:
- Subsection 36(3) of the Fisheries Act prohibits the deposit of a deleterious substance into water frequented by fish. Nothing in this Annex should be interpreted as an authorization or recommendation to ignore this prohibition.
- The recommendations described above are intended to complement road salt management procedures already established in areas identified, designated or protected by a local, provincial, territorial, aboriginal, national or international system or body as ecologically significant or ecologically important.

Considerations

When identifying vulnerable areas, organizations should consider

1. areas draining into bodies of water, such as
   (a) lakes and ponds with low-dilution and long residence times;
   (b) watercourses that experience the cumulative effects of a dense network of highways; and
   (c) provincially significant wetlands adjacent to roadways, where the addition of road salts has the potential to significantly raise the chloride concentration of the water to the point where it could present a threat of serious or irreversible environmental damage;

Annexe B : Conseils pour l'identification des zones vulnérables aux sels de voirie

Objet

L’annexe B a pour objet de fournir des conseils aux organisations à prendre en considération pour identifier, dans les milieux receveurs, les zones qui peuvent être particulièrement sensibles aux sels de voirie. Lorsqu’une zone vulnérable a été identifiée, on peut ensuite déterminer son degré de vulnérabilité et le besoin de prendre des mesures supplémentaires de gestion des sels de voirie.

Au nombre des mesures supplémentaires de gestion des sels de voirie possibles dans les zones vulnérables, on compte :
- le recours à des technologies qui optimisent davantage l’utilisation des sels de voirie;
- l’utilisation de solutions de remplacement des sels de voirie qui sont viables sur les plans environnemental, technique et économique;
- les activités de suivi et de mesure accrues des chlorures et/ou de leurs effets;
- le choix d’emplacements à l’extérieur des zones vulnérables pour les sites d’entreposage des sels de voirie et de la neige;
- la prise en considération de la position et de la protection des zones vulnérables dans la conception des nouvelles routes ou la réfection des routes existantes.

Lors de l’identification des zones vulnérables, il est important de noter qu’une zone pourrait être vulnérable soit aux rejets de sels de voirie peu fréquents mais importants, soit aux rejets faibles mais fréquents.

Une organisation peut envisager de consulter les entités qui œuvrent dans des domaines pertinents à l’identification de zones vulnérables aux sels de voirie. De plus, les organisations pourraient envisager l’échange d’information avec d’autres organisations qui sont adjacentes ou qui ont une autorité commune sur ces zones vulnérables, de même que la consultation de leurs citoyens.

Notes :
- Le paragraphe 36(3) de la Loi sur les pêches interdit d’immerger ou de rejeter une substance nocive dans des eaux où vivent des poissons. Aucune disposition de la présente annexe ne doit être considérée comme une permission ou une recommandation à l’encontre de cette interdiction.
- Il est à noter que les mesures indiquées ci-dessus visent à compléter les mesures de gestion des sels de voirie déjà mises en place dans les zones considérées ou désignées comme écologiquement importantes ou protégées à ce titre par des systèmes ou des organismes locaux, provinciaux, territoriaux, autochtones, nationaux ou internationaux.

Considérations

Lors de l’identification des zones vulnérables, les organisations devraient examiner :

1. les zones qui se drainent dans des plans d’eau, tels que :
   a) les lacs et les étangs caractérisés par une faible capacité de dilution et un long temps de séjour des substances introduites;
   b) les cours d’eau qui subissent les effets cumulés de réseaux routiers denses;
   c) les milieux humides d’importance provinciale bordant les routes,

où l’introduction de sels de voirie pourrait fortement augmenter la concentration de chlorure dans l’eau, au point de présenter des risques de dommages graves ou irréversibles à l’environnement;
2. areas draining into small, moderately deep lakes, where the addition of road salts has the potential to create layers of water of different salinity within the lake that prevent normal vertical mixing of the water (meromictic conditions);

3. areas where the addition of road salts has the potential to raise the chloride concentration, after mixing, to levels that could harm local fish or fish habitat;

4. areas adjacent to salt-sensitive native or agricultural vegetation, where the addition of road salts has the potential to cause severe reductions in flowering and fruiting, severe foliar, shoot and root injury, growth reductions, or reductions in germination and seedling establishment caused by elevated soil levels of sodium and chloride or aerial spray of sodium and chloride;

5. areas where the addition of road salts has the potential to harm the integrity of a life cycle (e.g. spawning grounds, nursery, rearing, food supply and migration areas for birds);

6. areas where the addition of road salts has the potential to harm a habitat necessary for the survival or recovery of a wildlife species listed on the List of Wildlife Species at Risk (Schedule 1 of the Species at Risk Act) where the area is identified as the species' critical habitat in the recovery strategy or in the action plan for the species established under that Act;

7. areas draining into sources of drinking water (surface water or groundwater, including wells), where the addition of road salts has the potential to raise the chloride concentration of the water to the point where it could not be used as a source of drinking water. Due regard should be given to background concentrations of chloride and other possible sources of chloride in making such a determination;

8. areas draining into groundwater recharge zones or that have an exposed or shallow water table, with medium to high permeability soils, such as medium to coarse sand and gravel, where the addition of road salts has the potential to significantly raise the chloride concentration of the groundwater to the point where it could present a threat of serious or irreversible environmental damage.

2. les zones qui se drainent dans de petits lacs de profondeur moyenne où l’introduction de sels de voirie pourrait créer des strates de salinité différente de l’eau et ainsi nuire au mélange vertical normal de l’eau (conditions méromictiques);

3. les zones où l’introduction de sels de voirie pourrait augmenter la concentration de chlorure après mélange à des niveaux pouvant affecter le poisson ou son habitat;

4. les zones voisines d’une végétation native ou agricole sensible aux sels, où l’introduction de sels de voirie pourrait entraîner une diminution marquée de la floraison et de la fructification des espèces sensibles ainsi que de graves dommages au feuillage, aux pousses et aux racines, ou une réduction de la croissance, de la germination et de l’établissement des jeunes plants dus aux fortes concentrations de chlorure et de sodium dans le sol ou à la dispersion de ces substances dans l’air;

5. les zones où l’introduction de sels de voirie pourrait nuire à l’intégrité d’un cycle biologique (par exemple, frayères ou lieux de reproduction, aires d’alevinage ou d’élevage, aires d’alimentation et haltes migratoires d’oiseaux);

6. les zones où l’introduction de sels de voirie pourrait dégrader un habitat nécessaire à la survie ou au rétablissement d’une espèce sauvage dont le nom figure sur la Liste des espèces en péril (annexe 1 de la Loi sur les espèces en péril) et considéré comme habitat essentiel dans la stratégie de rétablissement ou le plan d’action relatif à cette espèce établi en vertu de cette loi;

7. les zones qui se drainent vers des sources d’eau potable (eaux de surface ou eaux souterraines, incluant les puits) où l’introduction de sels de voirie fait augmenter la concentration de chlorure dans l’eau au point de rendre cette eau inutilisable comme source d’eau potable, en tenant dûment compte des concentrations ambiantes de chlorure et des autres sources possibles de chlorure;

8. les zones qui se drainent dans des zones d’alimentation d’une nappe d’eau souterraine, ou avec une nappe exposée ou proche de la surface, dont les sols sont moyennement à fortement perméables (par exemple, sable et gravier moyens à grossiers) et où l’introduction de sels de voirie pourrait fortement augmenter la concentration de chlorure dans les eaux souterraines, au point de présenter des risques de dommages graves ou irréversibles à l’environnement.

Annex C: Monitoring and Measuring Progress

The purpose of Annex C is to provide a common approach to monitoring and measuring progress in road salt use, the implementation of best management practices with respect to road salts, and the concentration of road salts in the environment. Information collected will be used in conjunction with additional winter severity weather data provided by the Meteorological Service of Canada, environmental monitoring data collected from case studies and water quality monitoring programs, and road safety data provided by Transport Canada to determine the extent and effectiveness of implementation of the Code of Practice.

Information to be provided to Environment Canada by organizations is described below.

1. Background Information

Organization
— Name and address;
— Technical contact, telephone and fax numbers, and electronic mail address;
— Population (municipalities only).

Annexe C : Suivi et mesure des progrès

L’annexe C a pour objet d’établir une approche commune pour le suivi et la mesure des progrès accomplis dans l’utilisation de sels de voirie, la mise en œuvre de pratiques de gestion optimales de ces sels et enfin, la concentration des sels de voirie dans l’environnement. L’information collectée sera utilisée conjointement aux données additionnelles sur la rigueur de l’hiver fournies par le Service météorologique du Canada, aux données de surveillance environnementale provenant d’études de cas et de programmes de surveillance de la qualité de l’eau et enfin, aux données de sécurité routière communiquées par Transports Canada, afin de déterminer l’étendue et l’efficacité de la mise en œuvre du code de pratique.

L’information à être communiquée à Environnement Canada par les diverses organisations est décrite ci-dessous.

1. Renseignements généraux

Organisation
— Nom et adresse;
— Personne-ressource pour le côté technique, numéros de téléphone et de télécopieur et adresse de courriel;
— Population (municipalités seulement).
Salt management plan
— Existence of a salt management plan;
— Date of approval of the salt management plan;
— Date of latest revision of the salt management plan, where applicable.

Road length serviced
— Total length of road on which salt is applied in the organization’s jurisdiction.

Winter severity
— Organization’s rating of the severity of the winter;
— Municipal Organizations Only — Total number of events requiring salt application during the winter averaged over all districts within the organization’s jurisdiction.

2. Materials Used
— Total quantity of road salts used for winter road maintenance;
— Description of non-chloride materials used for winter road maintenance.

3. Material Storage
— Organization’s objectives for implementing best management practices related to material storage, as indicated in its salt management plan;
— State of implementation of each management practice.

4. Winter Road Maintenance Equipment and Road Salt Application Practices
— Organization’s objectives for implementing best management practices related to road maintenance equipment and salt application practices, as indicated in its salt management plan;
— State of implementation of each management practice;
— State of calibration program for equipment.

5. Snow Disposal
— Organization’s objectives for implementing best management practices related to snow disposal, as indicated in its salt management plan;
— State of implementation of each management practice.

6. Winter Road Maintenance Training
— Existence of a winter road maintenance training program related to the organization’s salt management plan;
— Organization’s objectives for training of personnel, as indicated in its salt management plan;
— State of training of personnel.

7. Areas Vulnerable to Road Salts
— Existence of areas vulnerable to road salts;
— Description of additional salt management practices undertaken by the organization in identified vulnerable areas, where applicable.

Plan de gestion des sels de voirie
— Existence d’un plan de gestion des sels de voirie;
— Date d’approbation du plan de gestion des sels de voirie;
— Date, s’il y a lieu, de la plus récente révision du plan de gestion des sels de voirie.

Kilométrage total entretenu
— Longueur totale des voies où il y a épandage de sel dans la juridiction de l’organisation.

Rigueur de l’hiver
— Indice attribué par l’organisation à la rigueur de l’hiver;
— Organisations municipales seulement — Moyenne, pour toutes les régions sous la juridiction de l’organisation, du nombre total d’événements nécessitant l’épandage de sel en hiver.

2. Produits utilisés
— Quantité totale des sels de voirie utilisés pour l’entretien hivernal des routes;
— Description des produits, autres que les chlorures, utilisés pour l’entretien hivernal des routes.

3. Entreposage des produits
— Objectifs de l’organisation devant permettre de mettre en œuvre les pratiques de gestion optimaux pour l’entreposage des produits, selon les indications données dans son plan de gestion des sels de voirie;
— État d’avancement de la mise en œuvre de chaque pratique de gestion.

4. Équipement pour l’entretien hivernal des routes et pratiques d’épandage de sels de voirie
— Objectifs de l’organisation devant permettre de mettre en œuvre les pratiques de gestion optimaux pour l’équipement d’entretien des routes et les techniques d’épandage des sels, selon les indications données dans son plan de gestion des sels de voirie;
— État d’avancement de la mise en œuvre de chaque pratique de gestion;
— État d’avancement du programme de l’étalonnage de l’équipement.

5. Élimination de la neige
— Objectifs de l’organisation devant permettre de mettre en œuvre les pratiques de gestion optimaux pour l’élimination de la neige, selon les indications données dans son plan de gestion des sels de voirie;
— État d’avancement de la mise en œuvre de chaque pratique de gestion.

6. Formation pour l’entretien hivernal des routes
— Existence d’un programme de formation pour l’entretien hivernal des routes dans le cadre du plan de gestion des sels de voirie de l’organisation;
— Objectif de l’organisation en matière de formation de personnel, selon les indications données dans son plan de gestion des sels de voirie;
— État d’avancement de la formation du personnel.

7. Zones vulnérables aux sels de voirie
— Existence de zones vulnérables aux sels de voirie;
— Description, s’il y a lieu, de pratiques additionnelles de gestion des sels de voirie, appliquées par l’organisation dans les zones vulnérables identifiées.
8. Environmental Monitoring
— Chloride concentration and frequency of sampling at each
sampling location, if available.

DEPARTMENT OF THE ENVIRONMENT

CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

Notice with respect to the Guidelines for the Reduction of
Ethylene Oxide Releases from Sterilization Applications

Whereas ethylene oxide is a substance on the Priority Sub-
stances List, a list compiled under the Canadian Environmental
Protection Act, 1999;

Whereas the scientific assessment conducted on this substance
has concluded that ethylene oxide emits the environment in a
quantity or concentration or under conditions that constitute or
may constitute a danger in Canada to human life or health;

Whereas on April 13, 2002, the Minister of the Environment
and the Minister of Health published in the Canada Gazette,
Part I, a statement under subsection 77(6) of that Act indicating
their intention to recommend that ethylene oxide be added to
Schedule 1 of that Act;

Whereas, pursuant to subsection 54(1) of that Act, the Minister
of the Environment shall issue release guidelines recommending
limits, including limits expressed as concentrations or quantities,
for the release of substances into the environment from works,
undertakings or activities;

Whereas the Guidelines for the Reduction of Ethylene Oxide
Releases from Sterilization Applications are intended to fulfill the
requirement enacted in section 91 of that Act, to propose preven-
tive or control actions within two years after the Minister of the
Environment and the Minister of Health have published a state-
m ent under subsection 77(6) in the Canada Gazette;

Therefore, the Minister of the Environment is hereby pleased to
propose to issue, pursuant to subsection 54(1) of that Act, the
Guidelines for the Reduction of Ethylene Oxide Releases from
Sterilization Applications, in accordance with the schedule hereto.

Any person may, within 60 days after the publication of this
notice, file with the Minister of the Environment comments with
respect to the proposed Guidelines or a notice of objection request-
 ing that a board of review be established under section 333
of that Act and stating the reasons for the objection. All com-
ments and notices must cite the Canada Gazette, Part I, and the
date of publication of this notice, and be addressed to the Direc-
tor, Chemicals Control Branch, Environmental Protection Ser-
vice, Department of the Environment, Ottawa, Ontario K1A 0H3.

A person who provides information to the Minister may submit
with the information a request for confidentiality under sec-
tion 313 of that Act.

DAVID EGAR
Director General
Pollution Prevention Directorate
On behalf of the Minister of the Environment

MINISTÈRE DE L'ENVIRONNEMENT

LOI CANADIENNE SUR LA PROTECTION DE
L'ENVIRONNEMENT (1999)

Avis concernant les Lignes directrices pour la réduction des
rejets d'oxyde d'éthylène provenant de la stérilisation

Attendu que la substance oxyde d'éthylène figure sur la Liste
des substances d'intérêt prioritaire établie en vertu de la Loi
canadienne sur la protection de l'environnement (1999);

Attendu que l'évaluation scientifique de cette substance a per-
mis de conclure que l'oxyde d'éthylène pénètre dans l’environne-
ment en une quantité ou en une concentration ou dans des condi-
tions de nature à constituer ou à pouvoir constituer un danger au
Canada pour la vie ou la santé humaines;

Attendu que le ministre de l’Environnement et le ministre de la
Santé ont publié dans la Partie I de la Gazette du Canada, le
13 avril 2002, une déclaration conformément au paragraphe 77(6)
de cette loi indiquant leur intention de recommander que la sub-
tance oxyde d'éthylène soit ajoutée à l’annexe I de cette loi;

Attendu que, conformément au paragraphe 54(1) de cette loi, le
ministre de l’Environnement établit des directives énonçant les
maximaux recommandés, notamment en termes de quantité ou de
concentration, pour le rejet de substances dans l’environnement
par des ouvrages, des entreprises ou des activités;

Attendu que les Lignes directrices pour la réduction des rejets
d'oxyde d'éthylène provenant de la stérilisation visent à satisfaire
l'exigence prescrite à l'article 91 de cette loi, qui est de proposer
des mesures de prévention ou de contrôle dans les deux ans sui-
vant la publication conformément au paragraphe 77(6), d'une
déclaration dans la Gazette du Canada par le ministre de l’Envi-
ronnement et le ministre de la Santé;

À ces causes, il faut au ministre de l’Environnement de propo-
sé d'établir, en vertu du paragraphe 54(1) de cette loi, les Lignes
directrices pour la réduction des rejets d'oxyde d'éthylène prov-
enant de la stérilisation conformément à l’annexe ci-après.

Les intéressés peuvent présenter au ministre de l’Environne-
ment, dans les 60 jours suivant la date de publication du présent
avis, leurs observations au sujet du projet de lignes directrices ou
un avis d’opposition motivé demandant la constitution de la
commission de révision prévue à l’article 333 de cette loi. Ils sont
priés d’y citer la Partie I de la Gazette du Canada, ainsi que la
date de publication, et d’envoyer le tout au Directeur, Direction
du contrôle des produits chimiques, Service de la protection de
l'environnement, Ministère de l’Environnement, Ottawa (Ontario)
K1A 0H3.

Quiconque fournit des renseignements au ministre peut présen-
ter en même temps une demande de traitement confidentiel aux
termes de l’article 313 de cette loi.

Le directeur général
Direction générale de la prévention de la pollution
DAVID EGAR
Au nom du ministre de l’Environnement
Grain Processing Corporation
MATERIAL SAFETY DATA SHEET

SECTION I - Product and Company Identification

Product: MOUNTAIN MELT™ deicer

Chemical Name: Trade secret

Formula: Proprietary

Manufacturer: Grain Processing Corporation, P.O. Box 349, 1600 Oregon Street, Muscaline, Iowa 52761

24-Hour Emergency Assistance: 563-264-4304
For Other Information, Call: 563-264-4265

SECTION II - Ingredients

<table>
<thead>
<tr>
<th>Ingredient(s):</th>
<th>CAS No.</th>
<th>% by Wt.</th>
<th>OSHA PEL</th>
<th>ACGIH TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade secret</td>
<td>--</td>
<td>--</td>
<td>TWA</td>
<td>STEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TWA</td>
<td>STEL</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-0-0</td>
<td>SARA</td>
</tr>
</tbody>
</table>

NFPA-Hazard Identification: This system identifies the hazards in three categories: Health, Flammability, and Reactivity and indicates the order of severity ranging from 4 indicating a severe hazard to 0 indicating no special hazard.

SARA-EPA SARA Title III Hazard Categories: 1-Fire Hazard, 2-Sudden Release of Pressure, 3-Reactive, 4-Immediate (Acute) Health Hazard, 5-Delayed (Chronic) Health Hazard.

SECTION III - Physical Data

Boiling Point (°F): Not available
Vapor Pressure (mm Hg): Not available
Vapor Density (Air=1): Not available
Solubility in Water: Soluble
Appearance and Odor: Light blue crystalline solid; slight odor

Specific Gravity (H2O=1): ~2.2
Evaporation Rate (n-BuAc=1): Not available
Melting Point: Not applicable
pH: Neutral

SECTION IV - Fire and Explosion Hazard Data

Flash Point (Method Used): Not applicable
Flammable Limits: LeL - Not applicable, UEL - Not applicable
Extinguishing Media: Water, carbon dioxide, or dry chemical
Special Fire Fighting Procedures: Wear proper fire-fighting equipment
Unusual Fire and Explosion Hazards: None

SECTION V - Health Hazard Data

Route(s) of Entry: Inhalation - none. Skin - unlikely. Eyes - yes. Ingestion - unlikely.
Carcinogenicity: NTP - no. IARC - no. OSHA - no.
Threshold Limit Value: See Section II
Acute Oral Toxicity (rat): Low acute oral toxicity; LD50 for rats is >3 g/kg.
Skin Contact: May cause irritation.
Eye Contact: May be irritating to eyes.
Inhalation: None

Effects of Overexposure: Acute signs and symptoms as listed.
Emergency and First Aid Procedures:
  Ingestion: If large quantities are ingested, seek medical supervision.
  Skin Contact: Wash skin with water and mild soap. If irritation occurs, seek medical attention.
  Eye Contact: Flush eyes with plenty of water for 30 minutes. Get medical attention if warranted.
  Inhalation: None required.
SECTION VI - Reactivity Data

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): May be corrosive to light metals.

Hazardous Decomposition Products: Thermal decomposition may produce oxides of carbon.

Hazardous Polymerization: Will not occur.

SECTION VII - Spill or Leak Procedures

Steps to Be Taken in Case Material Is Released or Spilled: Sweep or vacuum spilled material.

Waste Disposal Method: Dispose of in approved solid waste disposal area per current regulations.

SECTION VIII - Special Protection Information

Personal Protective Equipment: Protective clothing, gloves and safety eyewear protection are not required, but recommended. Use appropriate NIOSH-approved respirator when needed. Respirator selection must be based on contamination levels found in the work area. Comply with OSHA standards 29 CFR 1910.134 Respirator Protection and 29 CFR 1910.1000 Air Contaminants Permissible Exposure Limits. Eyewash and safety shower should be available. Follow good housekeeping and manufacturing practices.

Ventilation: Use general or local exhaust ventilation to meet OSHA PELs or ACGIH TLV requirements.

SECTION IX - Special Precautions

Precautions to Be Taken in Handling and Storing: Store in a dry area.

Other Precautions: None

SECTION X - Transportation (DOT Information)

Department of Transportation - Classification: Not applicable

Department of Transportation - Identification Number: Not applicable

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees.

GPC-MSDS
MOUNTAIN MELT™
Effective Date: 04/02/02
Mountain Melt™

DEICER

Melts a Mountain of Snow and Ice!

MOUNTAIN MELT™ deicer is a special blend of granular material treated with a liquid enhancer formulated from an environmentally safe, agricultural-based product. MOUNTAIN MELT™ deicer is extremely effective at lower temperatures due to its lower freezing point and faster ice-melting action.

- Works to -10°F
- Reduces Refreezing
- Easy to See
- Doesn't Stain Carpets
- Works Quicker at Lower Temperatures
- Works Longer and is Safer for the Environment than Conventional Salts
- Helps Prevent “Black Ice”
- Reduces Corrosion
- Packaged in 20-lb and 50-lb Bags

Outperforms Other Deicers!

Grain Processing Corporation • Horizon Products Division
1600 Oregon Street • Muscatine, IA 52761 • USA • Phone: 563-264-4265 • FAX: 563-264-4289
www.grainprocessing.com

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©2002 Grain Processing Corporation MOUNTAIN MELT™ is a trademark of Grain Processing Corporation

JMC0402
GEOMELT® 55 Anti-icing Fluid

DESCRIPTION

GEOMELT® 55 anti-icing fluid is a natural, agricultural product that features ice control performance equal or superior to traditional brines, but less corrosive. GEOMELT® 55 anti-icing fluid is derived from renewable resources providing an attractive choice where environmental concerns are important. GEOMELT® 55 anti-icing fluid passes the strict specifications of the Pacific Northwest Snowfighters.

TYPICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Brown</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>10.5 pounds per gallon (1.26 kg per liter)</td>
</tr>
<tr>
<td>pH</td>
<td>8.5</td>
</tr>
<tr>
<td>Water Miscibility</td>
<td>Complete</td>
</tr>
</tbody>
</table>

APPLICATIONS

GEOMELT® 55 anti-icing fluid is highly effective for anti-icing, prewetting, salt/sand stockpile treatment, and bulk material freezeproofing. The suggested usage levels should be considered as starting points and should be adjusted as needed based on operator experience and to meet local conditions such as current and expected road and air temperatures, precipitation, traffic volume, etc.

Anti-Icing

- Apply at 20 to 30 gallons per lane mile (47 to 71 liters per kilometer).
- Stream apply. Do not fan spray or mist.
- Begin application when the pavement temperature is expected to drop to 32°F (0°C) or below, ideally as precipitation is beginning.

Benefits:
- Prevents ice and snow from sticking to the pavement, making removal easier.
- Lowers maintenance costs by reducing applications/quantities needed.
- No dust-causing abrasives needed.

Prewetting

- Apply at 5 to 10 gallons per ton (21 to 42 liters per metric ton) at the spinner or directly to the salt/sand during loading.

Benefits:
- Enhances the deicing performance of dry salt/sand.
- Starts the deicing process immediately.
- Reduces bounce and scatter losses during application from 30% loss down to only 4% loss. Prewetted salt/sand stays on the road.
- Less salt/sand is needed for the same effectiveness.

GEOMELT® anti-icing/deicing fluids are produced under U.S. Patent #6,080,330. Additional patents are pending.

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Salt/Sand Stockpile Treatment

- Apply at 6 to 8 gallons per ton of salt (25 to 33 liters per metric ton) or 5 to 6 gallons per ton of sand (21 to 25 liters per metric ton). Mix well.

Benefits:
- Keeps the stockpile free flowing. Prevents freezing or chunking.
- Reduces the corrosive properties of treated materials.
- Enhances the deicing performance of dry salt/sand.
- Reduces bounce and scatter losses during application from 30% loss down to only 4% loss. Prewetted salt/sand stays on the road.
- Less salt/sand is needed for the same effectiveness.

Bulk Material Freezeproofing

- Apply 2 to 4 pints per ton (1 to 2 liters per metric ton) by overhead spray to aggregates, coal, glass, or bulk materials for shipment.

Benefits:
- Safe to use with many materials.
- Keeps materials free flowing.
- Prevents freezing or chunking during transfers and shipment.
- Reduces the corrosive properties of treated materials.

Deicing

Although developed primarily as an anti-icer, GEOMELT® 55 anti-icing fluid is also an effective deicer when mixed with salt brine. Since overall chloride concentration is lower, corrosion is reduced.

- Blend 1 to 1 with salt brine. Mix thoroughly.
- Stream apply. Do not fan spray or mist.
- Apply 20 to 30 gallons per lane mile (47 to 71 liters per kilometer) depending upon accumulation.
- Allow to penetrate accumulation then plow as usual.

Benefits:
- Eats through hardpack to spread along the pavement.
- Breaks the bond between the ice and snow and the roadway.
- Makes removal easier.
- No dust-causing abrasives needed.

PERFORMANCE

GEOMELT® 55 anti-icing fluid is supplied ready to use and is designed as a direct replacement for salt brine in existing equipment. However, GEOMELT® 55 anti-icing fluid works at temperatures where salt brine is no longer effective. Anti-icing performance equal to salt brine can be achieved with less GEOMELT® 55 anti-icing fluid; therefore, fewer gallons are needed to achieve the same performance as salt brine. That means more lane miles per truckload with less equipment corrosion.
Freezing Point Depression

1. **Effect of Dilution on Freezing Point** - GEOMELT® 55 anti-icing fluid has a freezing point of -44.0°F (-42.2°C), which is 38.8°F (21.5°C) lower than salt brine as shown in the following graph and table.

![Dilution Effect on Freezing Point Graph](image)

<table>
<thead>
<tr>
<th>% Original Strength</th>
<th>GEOMELT® 55</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>32.0 (0)</td>
<td>17.9 (-7.9)</td>
<td>4.6 (-15.4)</td>
<td>-13.8 (-25.4)</td>
<td>-30.0 (-34.5)</td>
<td>-44.0 (-42.2)</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>32.0 (0)</td>
<td>25.6 (-3.6)</td>
<td>18.0 (-7.8)</td>
<td>7.7 (-13.5)</td>
<td>0.7 (-17.4)</td>
<td>-5.2 (-20.7)</td>
</tr>
</tbody>
</table>

GEOMELT® 55 anti-icing fluid not only offers performance superior to salt brine, but its superior anti-icing performance remains even after subsequent precipitation dilutes the product. For example, referring to the above graph, when diluted to 72% of its original strength, GEOMELT® 55 anti-icing fluid still performs as effectively as freshly applied salt brine.

2. **Phase Diagram** - Refer to the attached graph for a phase diagram of GEOMELT® 55 anti-icing fluid, NaCl brine, and CaCl₂ brine.

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*GEOMELT® anti-icing/deicing fluids are produced under U.S. Patent #6,080,330. Additional patents are pending.*

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**Viscosity**

In addition to its superior anti-icing performance, GEOMELT® 55 anti-icing fluid is more viscous than salt brine, particularly at reduced temperatures, making it especially suited for anti-icing applications where runoff is a problem. However, GEOMELT® 55 anti-icing fluid is still fluid enough to flow readily during application. Viscosity profiles at various temperatures are shown in the following graph and table.

![Viscosity Graph](image)

**Viscosity (centipoise)**

<table>
<thead>
<tr>
<th>Temperature °F (°C)</th>
<th>5 (-15)</th>
<th>15 (-9.4)</th>
<th>25 (-3.9)</th>
<th>75 (23.9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOMELT® 55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Strength</td>
<td>41.0</td>
<td>33.0</td>
<td>29.0</td>
<td>9.5</td>
</tr>
<tr>
<td>90% Strength</td>
<td>21.0</td>
<td>18.0</td>
<td>16.0</td>
<td>7.1</td>
</tr>
<tr>
<td>75% Strength</td>
<td>11.0</td>
<td>11.0</td>
<td>9.0</td>
<td>3.7</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>1.7</td>
<td>1.5</td>
<td>1.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

**Corrosion**

Test results from an independent lab approved by the Pacific Northwest Snowfighters have shown GEOMELT® 55 anti-icing fluid to be four times less corrosive than salt brine. In fact, GEOMELT® 55 anti-icing fluid when used with common anti-icing/deicing salts can help reduce equipment corrosion. GEOMELT® 55 anti-icing fluid can be an effective part of your corrosion control programs.
GEOMELT® 55 Anti-icing Fluid
Phase Diagram

GEOMELT® anti-icing fluid freezing points are based on Differential Scanning Calorimetry (DSC) data. The DSC data are useful for comparing anti-icer/deicer performance in a laboratory setting. Actual field observations may differ.

GEOMELT® anti-icing/deicing fluids are produced under U.S. Patent #6,080,330. Additional patents are pending.

This information is presented in good faith but is not warranted as to accuracy of results. Also, freedom from patent infringement is not warranted. This information is offered solely for your...
Grain Processing Corporation
MATERIAL SAFETY DATA SHEET

SECTION I - Product and Company Identification

Product: GEOMELT® 55 anti-icing fluid

Chemical Name: Trade secret

Formula: Proprietary

Manufacturer: Grain Processing Corporation, P.O. Box 349, 1600 Oregon Street, Muscatine, Iowa 52761

24-Hour Emergency Assistance: 563-264-4304
For Other Information, Call: 888-268-3561

SECTION II - Ingredients

<table>
<thead>
<tr>
<th>Ingredient(s):</th>
<th>CAS No.</th>
<th>% by Wt.</th>
<th>OSHA PEL</th>
<th>ACGIH TLV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade Secret</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NFPA-Hazard Identification: This system identifies the hazards in three categories: Health, Flammability, and Reactivity and indicates the order of severity ranging from 4 indicating a severe hazard to 0 indicating no special hazard.

SARA-EPA SARA Title III Hazard Categories: 1-Fire Hazard, 2-Sudden Release of Pressure, 3-Reactive, 4-Immediate (Acute) Health Hazard, 5-Delayed (Chronic) Health Hazard.

SECTION III - Physical Data

Boiling Point (°F): Not available
Vapor Pressure (mm Hg): Not available
Vapor Density (Air=1): Not available
Solubility in Water: Appreciable
Appearance and Odor: Dark aqueous solution; sweet odor

Specific Gravity (H₂O=1): 1.20 - 1.40
Evaporation Rate (n-BuAc=1): Not available
Melting Point: Not applicable
pH: ~9

SECTION IV - Fire and Explosion Hazard Data

Flash Point (Method Used): Not applicable
Flammable Limits: LeL - Not applicable. UEL - Not applicable
Extinguishing Media: Water, carbon dioxide, or dry chemical
Special Fire Fighting Procedures: Wear proper fire-fighting equipment
Unusual Fire and Explosion Hazards: None

SECTION V - Health Hazard Data

Route(s) of Entry: Inhalation - none. Skin - unlikely. Eyes - yes. Ingestion - unlikely.
Carcinogenicity: NTP - no. IARC - no. OSHA - no.
Threshold Limit Value: See Section II
Acute Oral Toxicity (rat): Low acute oral toxicity; LD₅₀ for rats is >5 g/kg.
Skin Contact: May cause irritation.
Eye Contact: May be irritating to eyes.
Inhalation: None
Effects of Overexposure: Acute signs and symptoms as listed.

Emergency and First Aid Procedures:
Ingestion: If large quantities are ingested, seek medical attention.
Skin Contact: Wash skin with water and mild soap. If irritation occurs, seek medical attention.
Eye Contact: Flush eyes with plenty of water for 30 minutes. Get medical attention if warranted.
Inhalation: None required.
SECTION VI - Reactivity Data

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): None.

Hazardous Decomposition Products: Thermal decomposition may produce oxides of carbon.

Hazardous Polymerization: Will not occur.

SECTION VII - Spill or Leak Procedures

Steps to Be Taken in Case Material Is Released or Spilled: All spills should be contained and picked up with earthen or other absorbent material and placed in suitable container.

Waste Disposal Method: Dispose of in approved solid waste disposal area per current regulations.

SECTION VIII - Special Protection Information

Personal Protective Equipment: Protective clothing, gloves and safety eyewear protection are not required, but recommended. Use appropriate NIOSH-approved respirator when needed. Respirator selection must be based on contamination levels found in the work area. Comply with OSHA standards 29 CFR 1910.134 Respiratory Protection and 29 CFR 1910.1000 Air Contaminants Permissible Exposure Limits. Eyewash and safety shower should be available. Follow good housekeeping and manufacturing practices.

Ventilation: Use general or local exhaust ventilation to meet OSHA PELs or ACGIH TLV requirements.

SECTION IX - Special Precautions

Precautions to Be Taken in Handling and Storing: Spilled material may be slippery. Clean up spills completely before walking in the area of spillage.

Other Precautions: None

SECTION X - Transportation (DOT Information)

Department of Transportation - Classification: Not applicable

Department of Transportation - Identification Number: Not applicable

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees.

GPC-MSDS
GEOMELT® 55
Effective Date: 10/24/02
BIOMELT® D55F Anti-icing/Deicing Fluid

DESCRIPTION

BIOMELT® D55F anti-icing/deicing fluid is made from a natural, agricultural product blended with potassium acetate liquid that features ice control performance equal or superior to traditional brines, but less corrosive. BIOMELT® D55F anti-icing/deicing fluid is derived from renewable resources providing an attractive choice where environmental concerns are important.

TYPICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear, translucent</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>10.6 pounds per gallon (12.7 kg per liter)</td>
</tr>
<tr>
<td>pH</td>
<td>8.9</td>
</tr>
<tr>
<td>Water Miscibility</td>
<td>Complete</td>
</tr>
</tbody>
</table>

APPLICATIONS

BIOMELT® D55F anti-icing/deicing fluid is highly effective for anti-icing and deicing. The suggested usage levels should be considered as starting points and should be adjusted as needed based on operator experience and to meet local conditions such as current and expected road and air temperatures, precipitation, traffic volume, etc.

Anti-icing

- For sidewalks and parking lots, apply 1 fluid ounce per square yard (35 ml per square meter).
- Apply using stream or fan spray.
- Begin application when the pavement temperature is expected to drop to 32°F (0°C) or below, ideally as precipitation is beginning.

Benefits:
- Prevents ice and snow from sticking to the pavement, making removal easier.
- Lowers maintenance costs by reducing applications/quantities needed.
- No dust-causing abrasives needed.

Deicing

- For sidewalks and parking lots, apply 2 fluid ounces per square yard (70 ml per square meter).
- Apply using stream or fan spray.
- Allow to penetrate accumulation then plow as usual.

Benefits:
- Starts thawing immediately. No sunshine needed.
- Eats through hardpack to spread along the pavement.
- Breaks the bond between the ice and snow and the roadway.
- Makes removal easier.

The information and recommendations in this publication are, to the best of the seller's knowledge, accurate. However, because of numerous factors affecting test results, seller makes no warranty of any kind, express or implied, other than the product conforms to its applicable current standard specifications. Statements concerning the use of the products or formulations described herein are not to be construed as recommending the infringement of any patent.
• No dust-causing abrasives needed.
• Less runoff than salt brine or potassium acetate liquid.

PERFORMANCE

BIOMELT® D55F anti-icing/deicing fluid is supplied ready to use and is designed as a direct replacement for salt brine in existing equipment. However, BIOMELT® D55F anti-icing/deicing fluid works at temperatures where salt brine is no longer effective. Anti-icing performance equal to salt brine can be achieved with less BIOMELT® D55F anti-icing/deicing fluid; therefore, fewer gallons are needed to achieve the same performance as salt brine. That means more area covered per truckload with less equipment corrosion.

Freezing Point Depression

1. **Effect of Dilution on Freezing Point** - BIOMELT® D55F anti-icing/deicing fluid has a predicted freezing point of -59.1°F (-50.6°C) which is 54°F (30°C) lower than salt brine as shown in the following graph and table.

![Dilution Effect on Freezing Point](image)

<table>
<thead>
<tr>
<th>% Original Strength</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>90% Predicted</th>
<th>100% Predicted</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOMELT® D55F</td>
<td>32.0 (0)</td>
<td>5.5 (-14.7)</td>
<td>-24.2 (-31.2)</td>
<td>-47.2 (-44)</td>
<td>-57.4 (-49.7)</td>
<td>-59.1 (-50.6)</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>32.0 (0)</td>
<td>25.6 (-3.6)</td>
<td>18.0 (-7.8)</td>
<td>7.7 (-13.5)</td>
<td>0.7 (-17.4)</td>
<td>-5.2 (-20.7)</td>
</tr>
</tbody>
</table>

BIOMELT® D55F anti-icing/deicing fluid not only offers performance superior to salt brine, but its superior anti-icing performance remains even after subsequent precipitation dilutes the product. For example, referring to the above graph, when diluted to 34% of its original strength, BIOMELT® D55F anti-icing/deicing fluid still performs as effectively as freshly applied salt brine.

2. **Phase Diagram** - Refer to the attached graph for a phase diagram of BIOMELT® D55F anti-icing/deicing fluid, NaCl brine, CaCl₂ brine, MgCl₂ brine, and potassium acetate liquid.
Viscosity

In addition to its superior ice-melting performance, BIOMELT® D55F anti-icing/deicing fluid is more viscous than salt-brine or potassium acetate liquid, particularly at reduced temperatures, making it especially suited for anti-icing applications where runoff is a problem. However, BIOMELT® D55F anti-icing/deicing fluid is still fluid enough to flow readily during application. Viscosity profiles at various temperatures are shown in the following graph and table.

<table>
<thead>
<tr>
<th>Temperature °F (°C)</th>
<th>BIOMELT® D55F</th>
<th>23% NaCl Brine</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (-15)</td>
<td>22</td>
<td>1.7</td>
</tr>
<tr>
<td>15 (-9.4)</td>
<td>14</td>
<td>1.5</td>
</tr>
<tr>
<td>25 (-3.9)</td>
<td>13</td>
<td>1.5</td>
</tr>
<tr>
<td>75 (23.9)</td>
<td>5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Corrosion

Testing has shown BIOMELT® D55F anti-icing/deicing fluid to be less corrosive than distilled water. BIOMELT® D55F anti-icing/deicing fluid can be an effective part of your corrosion control programs.
BIOMELT® D55F Anti-icing/Deicing Fluid

Phase Diagram

 BIOMELT® D55F
 NaCl Brine
 MgCl2 Brine
 CaCl2 Brine
 KAc

Predicted

Concentration, % DS

°F

40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80

0
5
10
15
20
25
30
35
40
45
50
55

°C

+4.4
+1.1
+6.7
+12.2
+17.8
+23.3
+28.9
+34.4
+40.0
+45.6
+51.1
+56.7
+62.2

BIOMELT® anti-icing/deicing product freezing points are based on Differential Scanning Calorimetry (DSC) data. The DSC data are useful for comparing anti-icer/deicer performance in a laboratory setting. Actual field observations may differ.

This information is presented in good faith but is not warranted as to accuracy of results. Also, freedom from patent infringement is not warranted. This information is offered solely for your investigation, verification, and consideration.

09/08/02
Grain Processing Corporation
MATERIAL SAFETY DATA SHEET

SECTION I - Product and Company Identification

Product: BIOMELT® DS5F anti-icing/deicing fluid
Chemical Name: Trade secret
Formula: Proprietary
Manufacturer: Grain Processing Corporation, P.O. Box 349, 1600 Oregon Street, Muscatine, Iowa 52761
24-Hour Emergency Assistance: 563-264-4304
For Other Information, Call: 563-264-4265

SECTION II - Ingredients

<table>
<thead>
<tr>
<th>Ingredient(s)</th>
<th>CAS No.</th>
<th>% by Wt.</th>
<th>OSHA PEL TWA</th>
<th>STEL</th>
<th>ACGIH TLV TWA</th>
<th>STEL</th>
<th>NFPA</th>
<th>SARA</th>
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<tr>
<td>Trade Secret</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1-0-0</td>
<td></td>
</tr>
</tbody>
</table>

NFPA-Hazard Identification: This system identifies the hazards in three categories: Health, Flammability, and Reactivity and indicates the order of severity ranging from 4 indicating a severe hazard to 0 indicating no special hazard.

SARA-EPA SARA Title III Hazard Categories: 1-Fire Hazard, 2-Sudden Release of Pressure, 3-Reactive, 4-Immediate (Acute) Health Hazard, 5-Delayed (Chronic) Health Hazard.

SECTION III - Physical Data

Boiling Point (°F): Not available
Vapor Pressure (mm Hg): Not available
Vapor Density (Air=1): Not available
Solubility in Water: Appreciable
Appearance and Odor: Clear, translucent aqueous solution; slight odor
Specific Gravity (H₂O=1): ~1.27
Evaporation Rate (n-BuAc=1): Not available
Melting Point: Not applicable
pH: ~8.9

SECTION IV - Fire and Explosion Hazard Data

Flash Point (Method Used): Not applicable
Flammable Limits: LEL - Not applicable UEL - Not applicable
Extinguishing Media: Water, carbon dioxide, or dry chemical
Special Fire Fighting Procedures: Wear proper fire-fighting equipment
Unusual Fire and Explosion Hazards: Decomposition products may be toxic

SECTION V - Health Hazard Data

Route(s) of Entry: Inhalation - yes. Skin - yes. Eyes - yes. Ingestion - unlikely.
Carcinogenicity: NTP - no. IARC - no. OSHA - no.
Threshold Limit Value: See Section II
Acute Oral Toxicity (rat): Low acute oral toxicity; LD50 for rats is >3 g/kg.
Skin Contact: May cause irritation.
Eye Contact: May be irritating to eyes.
Inhalation: May cause respiratory irritation.
- Effects of Overexposure: Acute signs and symptoms as listed.

Emergency and First Aid Procedures:
Ingestion: If ingested, seek medical supervision. Do not induce vomiting.
Skin Contact: Wash skin with water and mild soap. If irritation occurs, seek medical attention.
Eye Contact: Flush eyes with plenty of water for 30 minutes. Get medical attention if warranted.
Inhalation: Remove to fresh air. Seek medical attention if irritation persists.
SECTION VI - Reactivity Data

Stability: Stable

Conditions to Avoid: None

Incompatibility [Materials to Avoid]: Strong alkali, strong oxidizing or reducing agents.

Hazardous Decomposition Products: Thermal decomposition may produce oxides of carbon and the contained metal.

Hazardous Polymerization: Will not occur.

SECTION VII - Spill or Leak Procedures

Steps to Be Taken in Case Material Is Released or Spilled: All spills should be contained and picked up with earthen or other absorbent material and placed in suitable container.

Waste Disposal Method: Dispose of in approved solid waste disposal area per current regulations.

SECTION VIII - Special Protection Information

Personal Protective Equipment: Protective clothing, gloves and safety eyewear protection are not required, but recommended. Use appropriate NIOSH-approved respirator when needed. Respirator selection must be based on contamination levels found in the work area. Comply with OSHA standards 29 CFR 1910.134 Respiratory Protection and 29 CFR 1910.1000 Air Contaminants Permissible Exposure Limits. Eyewash and safety shower should be available. Follow good housekeeping and manufacturing practices.

Ventilation: Use general or local exhaust ventilation to meet OSHA PELs or ACGIH TLV requirements.

SECTION IX - Special Precautions

Precautions to Be Taken in Handling and Storing: Spilled material may be slippery. Clean up spills completely before walking in the area of spillage.

Other Precautions: None.

SECTION X - Transportation (DOT Information)

Department of Transportation - Classification: Not applicable

Department of Transportation - Identification Number: Not applicable

The information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determinations of suitability and completeness of information from all sources to assure proper use of these materials and the safety and health of employees.

GPC-MSDS
BIOMELT® D55F
Effective Date: 06/23/02
GEOMELT™ M Anti-icing/Deicing Fluid

DESCRIPTION

GEOMELT™ M anti-icing/deicing fluid is a natural, agricultural product blended with magnesium chloride liquid that features ice control performance equal or superior to traditional brines, but less corrosive. GEOMELT™ M anti-icing/deicing fluid is derived from renewable resources providing an attractive choice where environmental concerns are important. GEOMELT™ M anti-icing/deicing fluid passes the strict specifications of the Pacific Northwest Snowfighters.

TYPICAL PROPERTIES

Appearance: Brown
Specific Gravity
1.26
10.5 pounds per gallon
pH 7.4
Water Miscibility Complete

APPLICATIONS

GEOMELT™ M anti-icing/deicing fluid is highly effective for anti-icing, deicing, prewetting, and salt/sand stockpile treatment, and bulk material freeze-proofing. The suggested usage levels should be considered as starting points and should be adjusted as needed based on operator experience and to meet local conditions such as current and expected road and air temperatures, precipitation, traffic volume, etc.

Anti-icing

- Apply at 20 gallons per lane mile.
- Stream apply. Do not fan spray or mist.
- Begin application when the pavement temperature is expected to drop to 32° F or below. Ideally as precipitation is beginning.

Benefits:
- Prevents ice and snow from sticking to the pavement, making removal easier.
- Lowers maintenance costs by reducing applications/quantities needed.
- No dust-causing abrasives needed.

Deicing

- Apply 40 gallons per lane mile depending upon accumulation.
- Stream apply. Do not fan spray or mist.
- Allow to penetrate accumulation then plow as usual.

Benefits:
- Starts thawing immediately. No sunshine needed.
- Eats through hardpack to spread along the pavement.
- Breaks the bond between the ice and snow and the roadway.
- Makes removal easier.
- No dust-causing abrasives needed.
GEOMELT™ M Anti-icing/Deicing Fluid

Prewetting

- Apply at 8 to 10 gallons per ton at the spinner or directly to the salt/sand during loading.

Benefits:
- Enhances the deicing performance of dry salt/sand.
- Starts the deicing process immediately.
- Reduces bounce and scatter losses during application from 30% loss down to only 4% loss.
  Prewetted salt/sand stays on the road.
- Less salt/sand is needed for the same effectiveness.

Salt/Sand Stockpile Treatment

- Apply at 6 to 8 gallons per ton of salt or 5 to 6 gallons per ton of sand. Mix well.

Benefits:
- Keeps the stockpile free flowing. Prevents freezing or chunking.
- Reduces the corrosive properties of treated materials.
- Enhances the deicing performance of dry salt/sand.
- Reduces bounce and scatter losses during application from 30% loss down to only 4% loss.
- Prewetted salt/sand stays on the road.
- Less salt/sand is needed for the same effectiveness.

Bulk Material Freezeproofing

- Apply 2 to 4 pints per ton by overhead spray to aggregates, coal, glass, or bulk materials for shipment.

Benefits:
- Safe to use with many materials.
- Keeps materials free flowing.
- Prevents freezing or chunking during transfers and shipment.
- Reduces the corrosive properties of treated materials.

PERFORMANCE

GEOMELT™ M anti-icing/deicing fluid is supplied ready to use and is designed as a direct replacement for salt brine in existing equipment. However, GEOMELT™ M anti-icing/deicing fluid works at temperatures where salt brine is no longer effective. Anti-icing performance equal to salt brine can be achieved with less GEOMELT™ M anti-icing/deicing fluid; therefore, fewer gallons are needed to achieve the same performance as salt brine. That means more lane miles per truckload with less equipment corrosion.
GEOMELT™ M Anti-icing/Deicing Fluid

Freezing Point Depression

1. **Effect of Dilution on Freezing Point** - GEOMELT™ M anti-icing/deicing fluid has a freezing point of -41.4°F which is 36°F lower than salt brine as shown in the following graph and table.

![Graph showing freezing point depression](image)

<table>
<thead>
<tr>
<th>% Original Strength</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEOMELT™ M</td>
<td>32.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30% CaCl₂ Solution</td>
<td>32.0</td>
<td>24.3</td>
<td>9.9</td>
<td>1.4</td>
<td>-8.4</td>
<td>-19.9</td>
<td>-35.0</td>
<td>-57.5</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>32.0</td>
<td>25.6</td>
<td>18.0</td>
<td>14.4</td>
<td>10.4</td>
<td>5.9</td>
<td>0.7</td>
<td>-5.2</td>
</tr>
</tbody>
</table>

GEOMELT™ M anti-icing/deicing fluid not only offers performance superior to salt brine, but its superior anti-icing performance remains even after subsequent precipitation dilutes the product. For example, referring to the above graph, when diluted to 55% of its original strength, GEOMELT™ M anti-icing/deicing fluid still performs as effectively as freshly applied salt brine.

2. **Phase Diagram** - Refer to the attached graph for a phase diagram of GEOMELT™ M anti-icing/deicing fluid, NaCl brine, and CaCl₂ brine.
GEOMELT™ M Anti-icing/Deicing Fluid

Viscosity

In addition to its superior ice-melting performance, GEOMELT™ M anti-icing/deicing fluid is more viscous than salt brine, particularly at reduced temperatures, making it especially suited for anti-icing applications where runoff is a problem. However, GEOMELT™ M anti-icing/deicing fluid is still fluid enough to flow readily during application. Viscosity profiles at various temperatures are shown in the following graph and table.

![Graph showing viscosity data for GEOMELT™ M and NaCl Brine](image)

<table>
<thead>
<tr>
<th>Viscosity (centipoise)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
</tr>
<tr>
<td>GEOMELT™ M</td>
</tr>
<tr>
<td>100% Strength</td>
</tr>
<tr>
<td>80% Strength</td>
</tr>
<tr>
<td>60% Strength</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
</tr>
</tbody>
</table>

Corrosion

Test results from an independent lab approved by the Pacific Northwest Snowfighters have shown GEOMELT™ M anti-icing/deicing fluid to be seven times less corrosive than salt brine. GEOMELT™ M anti-icing/deicing fluid can be an effective part of your corrosion control programs.
GEOMELT™ M Anti-icing/Deicing Fluid

Phase Diagram

°F

0 5 10 15 20 25 30 35 40 45 50 55

Concentration, % DS

GEOMELT™ anti-icing/deicing product freezing points are based on Differential Scanning Calorimetry (DSC) data. The DSC data are useful for comparing anti-icing/deicer performance in a laboratory setting. Actual field observations may differ.

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GEOMELT™ anti-icing/deicing fluids are produced under U.S. Patent #6,080,330. Additional patents are pending.

The information and recommendations in this publication are, to the best of the seller's knowledge, accurate. However, because of numerous factors affecting test results, seller makes no warranty of any kind, express or implied, other than the product conforms to its applicable current standard specifications. Statements concerning the use of the products or formulations described herein are not to be construed as recommending the infringement of any patent.
BIOMELT® M Anti-icing/Deicing Fluid

DESCRIPTION

BIOMELT® M anti-icing/deicing fluid is made from a natural, agricultural product blended with magnesium chloride liquid that features ice control performance equal or superior to traditional brines, but less corrosive. BIOMELT® M anti-icing/deicing fluid is derived from renewable resources providing an attractive choice where environmental concerns are important.

TYPICAL PROPERTIES

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Clear, translucent</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.24</td>
</tr>
<tr>
<td></td>
<td>10.3 pounds per gallon</td>
</tr>
<tr>
<td>pH</td>
<td>4.9</td>
</tr>
<tr>
<td>Water Miscibility</td>
<td>Complete</td>
</tr>
</tbody>
</table>

APPLICATIONS

BIOMELT® M anti-icing/deicing fluid is highly effective for anti-icing, deicing, and prewetting. The suggested usage levels should be considered as starting points and should be adjusted as needed based on operator experience and to meet local conditions such as current and expected road and air temperatures, precipitation, traffic volume, etc.

Anti-icing

- Apply at 20 to 30 gallons per lane mile. For sidewalks and parking lots, apply 1 fluid ounce per square yard.
- Stream apply. Do not fan spray or mist.
- Begin application when the pavement temperature is expected to drop to 32°F or below, ideally as precipitation is beginning.

Benefits:
- Prevents ice and snow from sticking to the pavement, making removal easier.
- Lowers maintenance costs by reducing applications/quantities needed.
- No dust-causing abrasives needed.

Deicing

- Apply 40 gallons per lane mile depending upon accumulation. For sidewalks and parking lots, apply 2 fluid ounces per square yard.
- Stream apply. Do not fan spray or mist.
- Allow to penetrate accumulation then plow as usual.

Benefits:
- Starts thawing immediately. No sunshine needed.
- Eats through hardpack to spread along the pavement.
- Breaks the bond between the ice and snow and the roadway.
- Makes removal easier.
- No dust-causing abrasives needed.
BIOMELT® M Anti-icing/Deicing Fluid

Prewetting

- Apply at 5 to 10 gallons per ton of the spinner or directly to the salt/sand during loading.

Benefits:
- Enhances the deicing performance of dry salt/sand.
- Starts the deicing process immediately.
- Reduces bounce and scatter losses during application. Prewetted salt/sand stays on the road.
- Less salt/sand is needed for the same effectiveness.

PERFORMANCE

BIOMELT® M anti-icing/deicing fluid is supplied ready to use and is designed as a direct replacement for salt brine in existing equipment. However, BIOMELT® M anti-icing/deicing fluid works at temperatures where salt brine is no longer effective. Anti-icing performance equal to salt brine can be achieved with less BIOMELT® M anti-icing/deicing fluid; therefore, fewer gallons are needed to achieve the same performance as salt brine. That means more area covered per truckload with less equipment corrosion.

Freezing Point Depression

1. Effect of Dilution on Freezing Point - BIOMELT® M anti-icing/deicing fluid has a freezing point of -62.7°F which is 57.5°F lower than salt brine as shown in the following graph and table.

![Dilution Effect on Freezing Point](image)

<table>
<thead>
<tr>
<th>% Original Strength</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>60%</th>
<th>75%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOMELT® M</td>
<td>32.0</td>
<td>10.2</td>
<td>-10.5</td>
<td>-</td>
<td>-44.3</td>
<td>-</td>
<td>-62.7</td>
<td>-</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>32.0</td>
<td>25.8</td>
<td>18.0</td>
<td>14.4</td>
<td>-</td>
<td>5.9</td>
<td>0.7</td>
<td>-5.2</td>
</tr>
</tbody>
</table>

BIOMELT® M anti-icing/deicing fluid not only offers performance superior to salt brine, but its superior anti-icing performance remains even after subsequent precipitation dilutes the product. For example, referring to the above graph, when diluted to 44% of its original strength, BIOMELT® M anti-icing/deicing fluid still performs as effectively as freshly applied salt brine.

2. Phase Diagram - Refer to the attached graph for a phase diagram of BIOMELT® M anti-icing/deicing fluid, NaCl brine, MgCl₂, and CaCl₂ brine.

BIOMELT® M Anti-Icing/Deicing Fluid
Viscosity

In addition to its superior ice-melting performance, BIOMELT® M anti-icing/deicing fluid is more viscous than salt brine, particularly at reduced temperatures, making it especially suited for anti-icing applications where runoff is a problem. However, BIOMELT® M anti-icing/deicing fluid is still fluid enough to flow readily during application. Viscosity profiles at various temperatures are shown in the following graph and table.

![Viscosity Graph](image)

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>5°F</th>
<th>15°F</th>
<th>25°F</th>
<th>75°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOMELT® M</td>
<td>18</td>
<td>13</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>23% NaCl Brine</td>
<td>1.7</td>
<td>1.5</td>
<td>1.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Corrosion

Testing has shown BIOMELT® M anti-icing/deicing fluid to be 29% less corrosive than salt brine. BIOMELT® M anti-icing/deicing fluid can be an effective part of your corrosion control programs.
Memo

To: Steve Brown  
Kitchener ON Office

From: Sean Geddes  
Guelph ON Office

File: 160310697  
Date: January 28, 2009

Reference: Peer Review of Doon South - Thermal Regime Brief  
Overview of Ecoplans’ Input to SWM Design Process

As requested, I have completed a review of the document entitled Doon South – Thermal Regime, Overview of Ecoplans’ Input to the SWM Design Process, Draft – Without Prejudice (Ecoplans, December 22, 2008). It is my understanding that this draft has also been reviewed by Grand River Conservation Authority (GRCA) staff, and that their comments have been incorporated into a revised document. I was not involved in this or any other study related to either the Doon South proposal or the Upper Blair Creek Functional Drainage Study. My involvement in the current process is to provide a brief and cursory peer review to complement that completed by GRCA.

It is my understanding that studies and discussions have been ongoing for some time regarding the Doon South proposal and the proposed approach to stormwater management (SWM). It is also my understanding that monitoring requirements to ensure success of the system and contingency approaches to mitigate any unexpected failures of the system are to be developed during the final detail design of the SWM plan and implemented during operation of the plan.

Given these assumptions, I have completed my review and agree in general with the conclusions of the Ecoplans report and the commentary provided by GRCA. Overall, the premise of the SWM plan seems reasonable, assuming that the SWM design functions as intended. Scientific work completed by Ecoplans appears to support the concept, and monitoring is proposed to ensure that the design does function as intended. I would suggest that contingency plans should be developed that are fairly detailed and firm in the event that monitoring demonstrates that the intended function is not being met.

STANTEC CONSULTING LTD.

Sean Geddes  
Associate / Senior Project Manager  
sean.geddes@stantec.com
Doon South – Thermal Regime
Overview of Ecoplans’ Input to the SWM Design Process

Draft - Without Prejudice (Ecoplans, January 19, 2009)

Overview

This memo has been prepared to document Ecoplans Limited’s (Ecoplans) input to the Ontario Municipal Board (OMB) discussions / process in relation to the aquatic habitat system and associated thermal regime in Upper Blair Creek and its tributaries. Generally, Ecoplans’ input has occurred in two focal areas: fisheries / aquatic habitat and modeling for the existing condition thermal regime in the creek. The primary purpose of this memo is to provide more specific fisheries / aquatic input. However, to provide context, hydrological and thermal monitoring and SWM commentary is also provided.

The process of developing the ‘existing conditions’, ‘SWM design criteria’ and conceptual SWM design has involved extensive consultation among Ecoplans and GRCA biologists, MTE and Ecoplans hydrologists, and the broader project team involved in this review. A number of technical memos have been prepared and submitted to the broader OMB technical group – they are referenced where appropriate. Any ‘new’ or updated data / analyses not previously submitted are appended to this document.

This memo attempts to bring the various relevant technical pieces together in sufficient detail to provide the necessary context for the aquatic assessment.

It is important to distinguish between input that is intended for inclusion in the updated Upper Blair Creek Functional Drainage Study (FDS) and commentary / input to a conceptual Stormwater (SWM) strategy presented by MTE Consultants in their Technical Memo titled “Proposed Conditions Temperature Assessment” dated November 11, 2008 and discussed during the various technical meetings. The FDS commentary, which is outlined in Section A below, is intended as input to the broader-based guidelines and criteria that will guide the development of preliminary SWM designs in the upper Blair Creek watershed. Section B of this memo pertains to the conceptual SWM strategy proposed by MTE, discussed at the technical meetings and described in their Technical Memoranda. This section integrates Ecoplans’ biological assessment of the proposed SWM strategy and associated design criteria in relation to the aquatic habitat system and associated thermal regime in Blair Creek and its tributaries.

The various components of this process are described below.
**Fisheries / Aquatic Objective**

The over-arching biological objective of the ‘FDS thermal design criteria’ (guiding SWM Strategies in support of draft plans) is to maintain the existing aquatic habitat and thermal regime in Blair Creek in order to maintain the existing and potential seasonal habitat for sensitive coldwater species such as Brook Trout, where such habitat currently exists. Maintenance of the existing thermal regime depends on both groundwater (deep, shallow and interflow contributions) and surface water inputs to Blair Creek, and the macro and micro aquatic habitats to which they contribute.

Throughout this memo, the term ‘substantive change’ is used in relation to temperature. ‘Substantive change’ is defined as greater than 1°C, based on guidelines provided in MOE’s Stormwater Management Manual, with respect to coldwater systems. Additional clarification of how ‘substantive change’ is to be evaluated is provided at various points in the memo.

**Summary of Ecoplans’ Fisheries Biologist Input**

In support of the overall biological objective, Ecoplans’ input to the development of the design criteria included:

- Documentation of the existing habitat conditions in the upper reaches of Blair Creek, integrating Ecoplans’ and GRCA information (including 2008 studies), and consideration of scientific literature with respect to Brook Trout tolerances and ‘ideal’ or typical thermal ranges for various life cycle components.

- Characterization of the existing thermal regime in Blair Creek based on recorded information (GRCA permanent monitoring stations at New Dundee Road and Dickie Settlement Road), as well as representative modeling of thermal conditions (using GAWSER modeling information and geotechnical data to model average monthly instream temperatures and expected instream ‘normal’ and ‘extreme’ temperature ranges).

- Reviewing the SWM strategy and various technical memos prepared by MTE, and consulting with their hydrologists as well as the project hydrogeologists, Naylor Engineering Associates (NEA).
A. Functional Drainage Study

1. Existing Thermal Regime in Upper Blair Creek

Based on GRCA’s initial concern that there was insufficient existing conditions temperature data, Ecoplans developed a conceptual model that quantified the major contributions to streamflow and their corresponding influences on stream temperature of thermal regime. Through further review of the existing temperature data and review of the model results, it was concluded that the existing conditions temperature data were sufficient and verified through model results. Components of the model were provided at various technical meetings through July-August 2008 and the model / results were summarized in the “Technical Memo. Instream Targets for SWM Design, Blair Creek” (Ecoplans, September 17, 2008).

Key attributes of the model are as follows:

- The model was developed using Environment Canada’s climate normals from 1971 to 2000 (thirty years of average climate data, including temperature and precipitation), as well as the streamflow components generated by the existing conditions Gawser model (based on 39 years of data) developed for the study area by MTE Consultants.
- The model considered the variation of soil temperature with depth throughout the year, and the monthly variation of air temperature.
- Groundwater and surface water temperatures were then estimated, and based on the Gawser defined flow distribution, the flows were mixed to estimate the monthly average streamflow temperature.
- The results showed the relative contribution of the flow components on stream temperature, such as cooling by base flow in the summer and warming in the winter.

Subsequent discussion of this modeling approach at technical meetings lead to an independent assessment, by the GRCA, of approximately 10 years of measured temperature data from permanent stations at New Dundee Road and Dickie Settlement Road.

Statistical analyses of the ten years of monitoring data were compared to the modeled estimates of monthly average stream temperatures. The measured data were in generally in agreement with monthly average streamflow temperatures from the model (< 1˚C),
which validated the measured data and led to the conclusion that the 10 years of measured data could be used to characterize the existing thermal regime.

Results of the statistical analyses of the measured data included a tabular summary of the monthly mean stream temperature and its variation, as well as the 25th and 75th percentiles, and the maximum and minimum temperatures observed.

It was agreed that these data would describe the existing thermal regime by defining the mean monthly temperature, by providing the observed ranges of data fluctuation, and by indicating the extremes observed. This ‘Existing Condition’ summary is described in a memo prepared by Stantec Consulting Ltd. titled “Upper Blair Functional Drainage Study, Existing Blair Creek Temperature Regime, City of Kitchener” (final draft dated December 11, 2008). In addition, the ‘existing condition’ memo also specifies four distinct stream reaches, based on temperature regime and aquatic habitat data.

Comment. From a fisheries biology perspective, Ecoplans supports the ‘existing conditions’ as referenced in the Stantec memo, including both the characterization of the thermal regime, and the delineation of stream reaches. Ecoplans biologists have had input to the development of the agreed ‘existing conditions’ thermal regime throughout the process, including the initial modeling and analysis of measured gauge data. The thermal characterization and stream reach delineation reflects the fish habitat and community information collected to date.

2. Thermal Design Criteria

Design criteria are required to enable design of SWM facilities and develop site-specific implementation strategies that will maintain the existing thermal regime and associated aquatic habitat. The design criteria provide procedures, targets and conditions that are used to design specific components of a SWM strategy. Specific elements of a given strategy may vary from site to site, but the design criteria remain unchanged.

Although design criteria are intended to maintain the current thermal regime (i.e. instream temperature condition), they do not incorporate instream temperature itself, as instream temperatures are influenced by a variety of climatic and environmental parameters (e.g. air temperature, precipitation, watercourse shading). Instead, the design guidelines represent the performance standards to be achieved by any proposed SWM implementation strategy (e.g. changes to infiltration, SWM ponds, end-of-pipe facilities etc.) that, when met, should maintain the existing thermal regime.
The premise is that if these design guidelines are achieved, it is expected that the stream system will continue to function as it does now, and will continue to be characterized by the monthly mean stream temperatures, with their associated variations.

The ‘aquatic / fisheries’ objective for the thermal component of the system, as was specified by Ecoplans fisheries biologists at the outset of the OMB mediation process, is to maintain the existing aquatic habitat and thermal regime in Blair Creek in order to maintain the existing and potential seasonal habitat for sensitive coldwater species such as Brook Trout, where such habitat currently exists.

Based on this primary objective, Ecoplans biologists have provided input to the development of the ‘Design Guidelines’ memo currently in preparation. This input has considered the following:

- Review of the updated existing conditions information, with respect to aquatic habitat and fisheries. This is a composite of Ecoplans’ and GRCA data, that includes additional fish community surveys (GRCA spring 2008) and spawning surveys (Ecoplans fall 2008) to better characterize conditions from Reichert Drive to Reidel Drive.

Aquatic habitat / fish community sampling and spawning survey results are summarized in the “Technical Memo. Instream Targets for SWM Design, Blair Creek” (Ecoplans, September 17, 2008).

An updated aquatic resource overview is provided in Attachment 1 to this memo.

- Scientific literature review of optimal Brook Trout thermal requirements through life cycle stages. This is included in the “Technical Memo. Instream Targets for SWM Design, Blair Creek” (Ecoplans, September 17, 2008).

- Refined analyses for the MTE conceptual SWM Strategy (as outlined in the November 11, 2008 Technical Memo titled “Proposed Conditions Temperature Impact Assessment”). This additional refinement, presented in the “Draft Technical Memo. Proposed Conditions Temperature Impact Assessment – Duration Impacts (MTE December 9, 2008), was requested by Ecoplans fisheries biologist to refine our understanding of potential impacts. It is provided in Attachment 4 to this memo.

- Ecoplans’ thermal regime modeling results, as described in the “Technical Memo. Instream Targets for SWM Design, Blair Creek” (Ecoplans, September 17, 2008).

The primary ‘aquatic / fisheries’ objective has been further partitioned into objectives with respect to groundwater and surface water inputs. Five draft ‘design criteria’, which
have been documented in a memo prepared by the participants of the OMB technical meetings (latest draft titled “Temperature Targets – (Without Prejudice) (proposed JOINT SUBMISSION) dated December 10, 2008), have been developed to address both surface water and groundwater aspects, as outlined below.

Ecoplans’ has had biological input to the development of that draft, and additional commentary regarding the design criteria is provided in italics below. Based on our further review, we have proposed revised wording for the ‘draft criteria’, included as Attachment 2 to this memo.

**Managing Temperature of Groundwater Inputs**

The biological objective of these criteria is to maintain the groundwater discharge regime to the stream, which is important for supporting stream baseflow for aquatic biota in general and critical for maintaining certain coldwater habitat functions upon which Brook Trout rely for survival generally, and particularly during stressful periods and for successful spawning and recruitment. The groundwater discharge functions pertain to both general moderation of the stream flow, as well as direct discharge into the stream bed or margins.

1) Post development at-source infiltration will be greater than existing conditions and will be provided in a distributed manner.

*By maintaining and increasing existing at-source infiltration, groundwater will continue to move toward and discharge to the stream in a distributed manner, with the same thermal, temporal and spatial patterns as occur under existing conditions. Protecting these patterns will protect the functional relationships between the stream habitat and resident Brook Trout and other biota (both generally within the water column as well as specifically at discharge points that may support specific habitat components and particularly spawning or refuge functions).*

2) Where additional infiltration which provides additional groundwater input (end of pipe, conveyance) is proposed, a 6 month travel time is preferred to achieve ambient groundwater temperatures. Where 6 month travel time is not achievable due to soil conditions, technical studies such as geotechnical, hydrogeological, and biological are required to demonstrate that the temperature, flow rate and volume of that additional baseflow will not negatively impact on the thermal regime of Blair Creek and will not exceed the mean monthly instream temperatures.
If the 6 month travel time cannot be met, completion of these studies, supported with data collection and analysis as required, preserves the commitment to protect the thermal and flow regimes of the stream and the associated functional relationships that support the habitat used by Brook Trout and other biota. These studies would specifically verify that the temperature, flow rate and volume of that additional baseflow will not negatively impact the thermal regime of Blair Creek, including any specific coldwater habitat functions like spawning/egg incubation or seasonal refugia for Brook Trout that direct groundwater discharge might support. Maintenance of the other design criteria will protect the stream flow moderation and general living habitat functions. It is recognized that specific discharge relationships may require further assessment. The potential specific concern in relation to egg incubation over the winter, when there could be a concern regarding increasing the influx of shallower groundwater that might be slightly less moderated temperatures than the deeper groundwater, will be specifically assessed in these studies. However, as noted below, additional end-of-pipe infiltration will not be used in the winter.

The following comments are based on our current understanding of the system and the proposed SWM principles. It is generally recognized that in some areas, increased infiltration post development may provide ‘additional baseflow’ to the stream, potentially enhancing the stream baseflow in the upper reaches relative to the existing conditions. It is unlikely that ‘deeper’ groundwater discharges continuously to the upper reaches where flow is discontinuous or intermittent, such that it would support functions such as spawning or seasonal refugia. Some localized deeper groundwater discharge may occur in the lower portion of the upper reach where Brook Trout use occurs (i.e. between New Dundee Road and Dodge Drive).

It is anticipated that the proposed measures should protect the groundwater regime that might support important functions such as egg incubation or seasonal refugia, considering the dominance of the groundwater influx from at-source infiltration, relative to any additional infiltration occurring at the end-of-pipe, particularly during the winter months when this additional end-of-pipe infiltration is bypassed and surface flows are directed through the cooling trenches (which ‘warm’ storm discharge during winter months).

Furthermore, it is unlikely that any ‘additional baseflow’ sourced closer to the stream and moving to the stream as shallow groundwater or interflow would influence any functions maintained by the deeper groundwater. The shallow
groundwater would be unlikely to mix with the deeper groundwater, so the deeper groundwater contributions should be unaffected. In addition, it is not anticipated that the additional shallow groundwater would have a temperature much different (~1°C +/-) than the existing shallow component by the time the flow reached the creek. Regardless, the studies identified above will be required, during preliminary SWM design, to demonstrate this and verify that there are no substantive localized changes to the temperature of groundwater discharge to the stream (i.e., downgradient of SWM facilities).

Managing Temperature of Surface Water Inputs

The intent is to maintain volumes and temperatures of the surface water contributions to the creek. Existing runoff temperatures are defined or described as average monthly air temperatures. Runoff volumes are based on GAWSER modeling. The underlying biological objective of these criteria is to maintain the existing moderated streamflow and thermal regimes within the stream that support the coldwater habitat conditions, as represented by the ‘existing conditions’ as described in the Stantec December 11 2008 memo.

1. Surface water discharge from the cooling trenches (or other cooling measures) target is 19.2°C under normal climate conditions. This is based on average air temperature and it correlates to the GRCA gauge data at New Dundee Road (containing 10 years of average air temp data).

The intent is that the release of flow to the stream from the cooling trenches ‘matches’ the existing conditions surface runoff temperature. The proposed design criterion represents average summer conditions (June to August); Ecoplans recommend that the ‘extreme’ month, July, be used for design. In this case, the cooling trench release temperature for design would be 20.4°C. The intent is that this release temperature maintains the average July stream temperature (17.5°C). This temperature is within the optimal growth/feeding/activity range for Brook Trout, and well within the measured range of variability of stream temperatures over the summer months. Although there could be a concern with respect to the duration of discharge from cooling trenches at elevated temperature, the nature of these cooling facilities is such that temperature spikes should not occur. Moreover, the range of design temperatures for discharge is very narrow and the release rates are very low, so we anticipate no impact to stream temperatures. The magnitude of this potential effect should be demonstrated in the preliminary design and confirmed at detailed design, as outlined in Attachment 2.
2. Maximum surface water discharge will be 21°C under normal climate conditions. This maximum value recognizes the July and August monthly average air temperature (~20.0°C) and the lower lethal limit from literature review (22.0°C) completed by Ecoplans.

As previously indicated, we have recommended that the ‘extreme’ month, July, be used for design (i.e. 20.4°C). In this case, the surface water discharge temperature for design would be 21.2°C (which represents the average of the ‘July average’ and the lower end of the upper lethal limit, 22.0°C). This value is conservative. Such temperatures are routinely recorded in streams in southern Ontario that support Brook Trout. In addition to the temperature itself, the duration of the discharge at the maximum temperature is important. To address this concern, we recommend that the preliminary SWM design include analyses that show how the design criteria have been applied to demonstrate no substantive change to the average daily stream temperature during the discharge period associated with the design conditions (including extended detention release).

3. Principles of surface water discharge design: post development flow volumes are reduced to less than pre development volume and are released very slowly to provide maximum cooling measure contact time to achieve targets outlined above. It is recognized that cooling trenches or other measures may need to be in the groundwater table to assist in cooling surface discharge.

In detaining runoff in the pond, it is recognized that water continues to warm. Extending the release period over 4 days to maximize cooling contact time extends the period of post storm release. However, additional infiltration measures reduce the relative volume of total surface runoff to less than pre-development levels. The importance of considering the duration of this slightly elevated thermal release on the stream habitat and biota was recognized and a specific analysis was conducted to assess the short term implication of these releases during the design storm. Sensitivity analysis around the release temperatures was conducted by considering 2 design cases (stream release temperatures of 19.2 and 21°C, respectively). MTE’s December 9, 2008 Technical Memo titled “Proposed Conditions Temperature Impact Assessment – Duration Impacts” assessing this issue is provided in Attachment 4 to this memo. Based on this analysis, the predicted temperature changes are essentially unchanged, and would not be anticipated to have any harmful effect on the stream habitat or biota. During the entire 4 day design storm release in Case 1, and
during days 1 and 4 in Case 2, the temperature changes are actually very slightly lower in post development relative to pre-development (i.e., “better” or further moderated). Because the release volumes from the cooling trenches are so small relative to the balance of the stream flow moving through the system and the temperatures are only slightly different than the average stream temperature, the effect on overall temperatures is minimal.

**Summary.** From a fisheries biology perspective, Ecoplans’ fisheries biologists support the agreed-upon general design principles because they have been developed to address the over-riding aquatic / fisheries objective of maintaining the existing aquatic habitat and thermal regime in Blair Creek, which in turn will maintain the existing and potential seasonal habitat for sensitive coldwater species such as Brook Trout, where such habitat currently exists.

### 3. Monitoring

The proposed monitoring framework has been developed based on the following process:

- Based on discussion in the OMB technical meetings with respect to the MTE conceptual SWM Strategy, Ecoplans overview document (Oct 2008), in which key elements of the monitoring approach were identified.
- This draft generated subsequent discussion at tech meetings and GRCA requested clarification and refinement of the monitoring strategy.
- In response, Ecoplans has provided a revised Monitoring document (Dec 2008) (provided as Attachment 3 to this memo).

The proposed monitoring framework achieves 2 key objectives:

- Provides guidance in establishing the climate conditions under which the proposed SWM facilities are operating (e.g. warmer than ‘normal’, wetter than ‘normal’ etc.)

- Identifies the key components of the monitoring strategy. These will be used to verify that the existing thermal regime is being maintained.

It is important to note that the proposed Monitoring Strategy is intended to provide general guidance, including key parameters to measure, but that site-specific monitoring plans are to be developed as a condition of Draft Plan approval.
B. Comments on MTE SWM Strategy

MTE has prepared a SWM strategy ("Proposed Conditions Temperature Impact Assessment") which is intended to demonstrate that the preliminary design guidelines / temperature targets under discussion at the technical meetings could be met with an approach other than that specified in the UBCFDS (2007).

Based on our understanding of how the MTE proposed SWM strategy will work, there are 5 key components:

1. At-source infiltration (e.g. roof leaders and passive lot level measures)
2. End-of-pipe infiltration
3. End-of-pipe cooling trench (surface water discharge to stream)
4. Surface water discharge from SWM pond (for large storm events)
5. Contingency Measures

The MTE proposed strategy has been reviewed by Ecoplans ecologists throughout the duration of the OMB mediation process to provide a biological perspective. Each component is discussed below and an overall evaluation is provided at the end.

At-source Infiltration

Based on the premise that the post-development rate of at-source infiltration will meet or exceed pre-development levels, we do not expect any substantive change to the temperature of groundwater discharging to the stream for this component of the groundwater regime. As a result, there will be no substantive change to the temperature of any contributions of this at-source infiltration to baseflow in the creek.

End-of-pipe Infiltration

The proposed end-of-pipe infiltration at SWM ponds will generate additional groundwater volume, relative to the current condition.

Groundwater moves very slowly, so that the increased infiltration / additional groundwater volume from the end-of-pipe facility will generally not mix with the underlying groundwater. Increased infiltration will tend to be in the upper groundwater flow areas and will be exposed to marginally higher soil temperatures. This assumes that groundwater mounding is not an issue, or does not cause local conditions that would alter
the expected groundwater flow patterns. Based on expected depths and soil temperatures, the potential temperature difference in this ‘additional’ volume of groundwater will be in the order of 1°C or less, relative to current ambient groundwater temperatures. This expected temperature differential applies to the three seasons of operation (noting that end-of-pipe infiltration is bypassed during the winter months).

Based on our understanding of how the proposed SWM implementation will function, the potential impact to the thermal regime that supports coldwater aquatic habitat and fish from increased infiltration is anticipated to be minimal considering:

1. Groundwater temperatures in the summer range from 8 - 12°C, depending on depth (current condition), well below the average July stream temperature of 17.5°C;

2. The minimal increase in groundwater temperature for the ‘increased infiltration’ (~ 1°C, resulting in a net summer groundwater temperature of ~ 13°C, still well below the instream July average temperature)

3. There will be a reduction in overland flow at augmented temperatures (relative to the current condition), resulting in less potential for instream warming as a result of surface water inputs.

End-of-pipe Cooling Trench

The MTE SWM Strategy states that the End-of-pipe Cooling Trench will be designed such that discharges to the stream will occur at the same temperature as existing conditions surface runoff (as estimated by average monthly air temperature). For example, in July, the average monthly air temperature is 20.4°C which will be used as the design temperature target for cooling facilities.

The runoff volume that is not infiltrated (by the end-of-infiltration as discussed above) will be directed through the proposed cooling trench and ultimately discharge to the stream as surface runoff.

This runoff volume will be less than existing conditions, but it will be extended over a longer period (i.e. up to 4 days).

Surface water discharge from SWM pond (for large storm events)

Potential impacts for small storm events or at the beginning of large storm events are mitigated by the proposed end-of-pipe infiltration and end-of-pipe infiltration cooling trench. For larger storms (i.e., generally 2 year storm or higher return period), as those
storms evolve, there is no concern with respect to thermal impacts as a result of releases from the SWM facility. In other words, there is no opportunity for surface runoff to warm in SWM ponds.

At the end of these larger storms (i.e. when water remains in SWM ponds during the extended detention portion), discharge will go through the end-of-pipe infiltration and/or end-of-pipe cooling trench.

Contingency Measures

Ecoplans supports the inclusion of contingency measures for protection of aquatic habitat. Contingency measures are to be determined on a site-specific basis, based on general guidelines in the FDS, and specified in the preliminary SWM designs included in support of draft plan submissions.

Fisheries Biologist Review of the Strategy – Additional Analysis

Ecoplans’ fisheries-based input to the MTE strategy was primarily through the broader FDS review process, with respect to the development of the ‘design criteria’. To that end, we identified the general biological objectives (as described above) early in the process, which were conveyed to the broader FDS technical group, including MTE. Our evaluation of the proposed strategy, from a fisheries perspective, is based on the underlying premise that the strategy is consistent with the broader FDS design objectives.

To help clarify our assessment, Ecoplans requested specific thermal calculations from MTE. The intent of these subsequent analyses was to quantify: the change in duration of surface water discharge, the increased levels of baseflow and potential net impact to the instream thermal regime. In other words: “Does the increased baseflow from at-source and end-of-pipe infiltration balance the extended release from the cooling trench so that instream temperatures are maintained at existing levels?”

These subsequent analyses included calculations of daily flows under the 25 mm design storm for existing and post development conditions over the four day storm release duration (including extended detention). The calculations partitioned the flow components pre- and post- development measures of: 1) existing base flow; 2) additional base flow due to infiltration (at-source and end-of-pipe) and 3) surface flow (surface flow in pre-development or cooling facility release in post development). A temperature was assigned to each component reflecting the assumed design conditions. In addition, a sensitivity analysis was done to examine the impact of increased cooling temperatures to 21°C. These additional analyses are described in the Draft Technical Memo “Proposed...
Conditions Temperature Impact Assessment – Duration Impacts” (MTE December 9, 2008).

The key conclusion from these analyses is that potential temperature changes as a result of the proposed SWM implementation strategy are smaller than our ability to meaningfully monitor. More specifically, under the post-development condition, the average change in stream temperature during the 4-day design period is expected to decrease by 0.17°C (based on a 19.2°C cooling trench release temperature), and on each of the 4 days, the expected stream temperature was very slightly reduced from existing conditions.

To evaluate potential impacts to instream temperature of a higher cooling trench release temperature, a further sensitivity analysis was completed using a release temperature of 21°C. The net result of this analysis confirmed that no substantive change to post-development instream temperature is expected. The average expected increase was 0.02°C, with a maximum increase of 0.17°C on day 2 and a decrease of 0.15°C on day 4.

Given the magnitude of these differences, the pre- and post-development expected temperatures are considered equivalent.

As outlined in our commentary on the FDS design criteria, it is expected that further analysis will confirm that there are no substantive localized changes to the temperature of groundwater discharging to the stream (i.e. downgradient of SWM facilities).

Fisheries-based Assessment the SWM Strategy – Summary and Conclusions

The overall objective of the SWM strategy with respect to temperature, consistent with that of the overall FDS thermal design criteria, is to protect the existing aquatic habitat conditions in Blair Creek. The key ecological function is the groundwater-moderated thermal regime, which is critical in sustaining the coldwater habitat functions that support the resident Brook Trout community. Maintenance of the existing thermal regime is influenced by both groundwater and surface water inputs to Blair Creek. Maintenance of the functional relationships with the macro and micro aquatic habitat elements to which these flows contribute is also recognized by considering distribution patterns.

Brook Trout use in Blair Creek has been confirmed as far upstream as the reaches of the Dodge Drive Tributary and main channel of Upper Blair Creek between New Dundee Road and Dodge Drive (GRCA fisheries assessment, May 2008). Potential for seasonal use is present upstream of Dodge Drive (depending on flows, temperatures and groundwater contributions). It is anticipated that this potential for use by Brook Trout would vary year to year depending on the specific flow and thermal regime; stream form,
particularly under low flow conditions, also limits potential use by adult fish (e.g., limited pools, areas of poorly defined channel and discontinuous flow).

Although spawning has not been confirmed upstream of New Dundee Road, it has been confirmed immediately downstream, and scrapes that appear to reflect attempted spawning activity have been recorded immediately upstream of the road. The perched culvert outfall at New Dundee Road will also influence Brook Trout movement and distribution seasonally, and potentially year to year depending on flows.

By maintaining the existing flow, quality and thermal regimes in Blair Creek post-development, and specifically by maintaining groundwater supported micro-habitats (e.g., groundwater discharge that may support Brook Trout spawning and seasonal refugia), the underlying fish and aquatic habitat conditions that can support Brook Trout and other sensitive species in the various reaches of the stream will also be maintained.

The proposed MTE SWM strategy integrates both groundwater and surface water components. It is recognized that there is always some uncertainty involved in assessing the implications of SWM strategies on stream habitats, in that post development conditions cannot exactly replicate pre-development conditions. Continued, integrated, multi-disciplinary assessment during the SWM design process, and consideration of contingency measures in the design, are important in this regard.

To consider potential implications on fisheries, initially it must be demonstrated that the proposed SWM strategy meets the agreed upon ‘design criteria’ for the FDS (as determined by a SWM engineer / hydrogeologist-based assessment) described in the various technical memos and as reflected in the specific design criteria and principles outlined above.

In summary, Ecoplans can support the design principles outlined in the MTE SWM strategy, based on our understanding of the existing thermal regime and fish community and functions in upper Blair Creek, and our understanding of the manner in which the SWM Strategy will function in relation to the stream environment.

Our understanding is that preliminary SWM designs for development plans will include additional details regarding the design / implementation strategy (e.g. ‘mounding’ assessments) and site-specific refinements to the post-development monitoring plan. The more detailed analyses that will follow as the detailed designs of the SWM plans are developed will incorporate additional specific biological assessment including, for example, quantification of volume, duration and temperature of discharge, refined locations of discharge etc., integrated with additional field assessment, as appropriate, to
ensure the design considers the local aquatic habitat features and functions and Brook Trout life cycle requirements. The monitoring plans, including integral contingency measures, will ensure that the SWM is implemented effectively, in accordance with the FDS design criteria, to protect the aquatic habitat and fish community.
Attachment 1. Upper Blair Creek – Aquatic Resource Overview (Including 2008 field survey updates) – Ecoplans

This memo provides results of spawning surveys completed in fall 2008 and an overview of aquatic habitat in Upper Blair Creek. An initial discussion of aquatic reaches was included in September 17, 2008 Technical Memo “Instream Temperature Targets for SWM Design, Blair Creek” (Ecoplans 2008). That discussion has been updated in the current memo to reflect all recent field work.

Spawning Habitat Assessment

2004-2007

One spawning survey was completed between Dodge Drive and Reidel Drive on December 6, 2006. During that survey, no Brook Trout were recorded and there was no evidence of spawning (i.e. redds, scrapes or potential scrapes). Further, no Brook Trout were recorded during any of the other aquatic field surveys (8 dates in total).

For additional details, refer to the Stauffer Woods Subdivision, Stages 2-4 EIR (Ecoplans June 2008).

Fall 2008

To supplement previous data, fall Brook Trout spawning surveys were completed throughout the upper Blair Creek subwatershed.

Location

- ~ 100 m upstream of Reidel Drive to 50 m downstream of Reichert Drive

Timing

- October 31, 2008 (9 person hours in-field)
- November 12, 2008 (8 person hours in-field)
- November 27, 2008 (11 person hours in-field)

Methodology

Representative reach sections were identified based on previous work and initial fall 2008 reconnaissance survey. Refer to the attached figure for ‘spawning assessment reach’ locations.

- Each reach was walked and closely checked for evidence of scrapes, redds, upwellings and fish presence
- Aquatic habitat mapping notes were taken to update reach descriptions
GPS coordinates were taken for potential / confirmed spawning areas, upwellings etc.
Spot temperature measurements were taken
Representative photographs were taken

Key Results

- 1 confirmed spawning area (large pool immediately downstream of New Dundee Road)
  - 3 active redds (which appeared to increase in size from Oct 31 – Nov 12)
  - Significant groundwater upwelling present (visible upward flow and substantial amounts of iron floc)
  - 2 adult Brook Trout observed on redds (October 31st)
- 4 additional potential spawning areas recorded
  - 2 potential scrapes approximately 30 m downstream of confirmed redds at New Dundee Road pool
  - 1 potential scrape immediately downstream of Reichert Drive
  - 2 potential scrapes immediately upstream of New Dundee Road
  - 1 possible scrape ~ 330 m upstream of Dodge drive (located at existing wildlife / pedestrian crossing location – future proposed road crossing location)
- 2 Brook Trout observed on October 31st; none observed on other survey dates (November 12th or November 28th)

Habitat Reaches

Based largely on the groundwater/baseflow characteristics and associated flow and thermal regimes, Upper Blair Creek / Blair Creek can be sub-divided into four primary reaches, briefly characterized below. The aquatic habitat overview is based on field work completed by Ecoplans from 2004-2008 (including fall 2008 surveys), supplemented by other existing conditions information collected by GRCA. For additional details regarding survey dates and methodologies, refer to Stauffer Woods Subdivision, Stages 2-4 EIR (Ecoplans June 2008).

Reach 1. Upstream of New Dundee Road (main branch)

This includes three sub-reaches, described below.

Subreach 1a. Upstream of Reidel Drive

- It is generally agreed that the reaches upstream of Reidel Road do not support persistent enough flow or defined/continuous enough channel form to support even seasonal Brook Trout use.
Subreach 1b. Reidel Drive (BBB9) to Dodge Drive (BBB10)

- Some baseflow contribution inferred from BBB temperature data (narrow range of moderate summer temperatures ~12°C-16°C), although point measurements by Ecoplans in 2007/2008 were generally high (~18°C-20°C).
- Predominantly a ‘losing’ reach, though the actual transition point from ‘losing’ to ‘gaining’ reach is not precisely known and may fluctuate yearly.
- Intermittent - does not always support continuous flow through the summer.
- Broad low flat channel with some sections with poor or no channel form, until lower portion (~halfway through reach), where the channel is defined as a channelized / straightened section flowing through open meadow.
- No records of Brook Trout or evidence of spawning. Although one possible scrape was recorded ~ 330 m upstream of Dodge Drive, it is unclear if this was a scrape or disturbance of bed associated with access (this is at a narrow portion of the valley that wildlife use as a stream crossing point, in addition to recent pedestrian crossings at this location during agency site walks).
- Evidence of groundwater discharge at several points along this reach (i.e. iron floc and watercress).
- Ecoplans did not capture any fish upstream of the residential driveway just upstream of Dodge Drive during sampling in August 2007 / June 2008. However, Central Mudminnow and Brook Stickleback were caught immediately downstream of the residential driveway (between the driveway and Dodge Drive) during electrofishing in August 2007. In addition, 2 Brook Stickleback were trapped in an off-line pond adjacent to Dodge Drive (upstream side) in April 2008.
- Although there is potential for seasonal fish use when flows are sufficient, this potential is limited by: lack of refuge pools during low / no flow situations; sections of poorly defined channel that could limit fish movement; and the residential driveway culvert upstream of Dodge Drive, that is slightly perched during low flow conditions, presenting a seasonal barrier to upstream fish movement.

Subreach 1c. Dodge Dr. (BBB10) to New Dundee Rd. (BBB11)

- Includes both the main branch of Upper Blair Creek and the lower reach of the Dodge Drive tributary (from Dodge Drive to the confluence with the main branch).
- Transitional reach, from upstream ‘losing’ reaches to downstream ‘gaining’ reaches.
- Some baseflow contributions, supported by more consistent, cooler measured summer temperatures (~12°C -14°C) at New Dundee Road (BBB11) and evidence of groundwater discharge.
• Flows are variable and conditions may not support continuous flow through the summer every year.

• The majority of the lower sections through the swamp (including the Dodge Drive tributary lower reach) are comprised of low, spreading braided channel form with limited refuge pooling. In the upper portion of this reach downstream of Dodge Drive (i.e., outside of the treed swamp), the channel is narrow, but well defined with a lower width:depth ratio and undercut banks.

• GRCA fish sampling May 9, 2008 confirmed presence of multi-age class (juveniles to adult) Brook Trout in: the lower reach of the Dodge Drive tributary and in the main branch of Upper Blair Creek and within seasonally flooded pools in the swamp between New Dundee Road and Dodge Drive.

• No confirmed spawning activity was recorded. However, 2 scrapes that could indicate potential spawning attempts were recorded immediately upstream of New Dundee Road. In addition, evidence of groundwater discharge (i.e. watercress) was noted in this area. As noted, a single possible ‘scrape’ was also noted further upstream (~ 330 m upstream of Dodge Drive).

• The New Dundee Road culvert outfall is at least seasonally perched above a large scour pool, limiting fish access upstream, at least during low flow conditions. During the October / November 2008 surveys, the culvert was perched approximately 13 cm above the surface of the pool.

Reach 2  Dodge Drive Tributary (upstream of Dodge Drive)

• No defined channel immediately upstream of Dodge Drive (diffuse flow through Reed-canary Grass meadow marsh); short section of defined channel through the wooded portion of the Dodge Drive wetland (which conveys expressed groundwater in a very narrow channel ~ 0.5 m wide).

• Evidence of baseflow contributions, inferred by periods of relatively consistent ~13°C-16°C summer temperatures. A spring is present at the upstream end (west end of wooded portion of Dodge Drive wetland).

• May not support continuous flow through the summer months every year.

• No fish observed during any field surveys.

• Some potential for seasonal fish use when flows are sufficient. However, the lack of defined channel and refuge pools during low / no flows limit potential.
Reach 3  New Dundee Road (BBB11) to Reichert Drive (BBB1) (Upper Blair Creek)

- Evidence of baseflow contributions, inferred by low summer stream temperature (13°C per BBB) – groundwater discharge seepage zones, watercress, iron floc and substantial upwelling noted in pool immediately downstream of New Dundee Road.

- Beaver activity in lower portion of reach near Reichert Drive (backwater/impounding effect and associated downstream flow, local surface warming, deposition etc. effects).

- Confirmed Brook Trout habitat.

- Spawning activity confirmed (3 redds, 2 attendant adult Brook Trout) in scour pool at New Dundee Road culvert outfall.

Reach 4  Reichert Drive (BBB2) to Dickie Settlement Road (Blair Creek)

- Significant groundwater / baseflow contributions from discharge in Roseville Swamp – generally a moderated, narrow range of cold summer temperatures and moderated (‘warm’) winter temperatures.

- Permanent flow with confirmed Brook Trout use and good coldwater habitat.

- No confirmed spawning during fall 2008 surveys (which only extended ~ 50 m downstream of Reichert Drive), but one potential scrape noted immediately downstream of Reichert Drive.
Attachment 2. Ecoplans’ Recommended Edits to ‘Design Criteria’ Memo

Thermal Design Criteria – for Inclusion in the FDS

Managing Temperature of Groundwater Inputs

1) Post development at-source infiltration will be greater than existing conditions and will be provided in a distributed manner.

2) Where additional infiltration is proposed which provides additional groundwater input (end of pipe, conveyance) is proposed, a 6 month travel time is preferred to achieve ambient groundwater temperatures. Where 6 month travel time is not achievable due to soil conditions, technical studies such as geotechnical, hydrogeological, and biological are required to demonstrate that the temperature, flow rate and volume of that additional baseflow will not negatively impact on the thermal regime of Blair Creek and will not exceed the mean monthly instream temperatures.

Managing Temperature of Surface Water Inputs

The intent is to maintain volumes and temperatures of the surface water contributions to the creek. Existing runoff temperatures are defined or described as the average monthly air temperatures. Runoff volumes are based on GAWSER modeling.

For the purposes of design (based on the design condition as the 25 mm, 4 hour storm):

1. The average design surface water discharge temperature from the cooling trenches (or other cooling measures) is 20.4°C (for July) under normal climate conditions. This is based on average air temperature and it correlates to the GRCA gauge data at New Dundee Road (containing 10 years of average air temperature data). The average July SWM pond release temperature entering the cooling facility should be used for design.

2. The maximum design surface water discharge temperature is 21.2°C under normal climate conditions. This maximum value recognizes the July and August monthly average air temperature (20.4°C) and the lower range of the upper lethal limit for Brook Trout (~22°C), based on the literature review completed by Ecoplans and discussions with GRCA.

3. Principles of surface water discharge design: there is no increase in post-development flow volumes relative to pre-development levels and flows are
released very slowly to provide maximum cooling measure contact time to achieve targets outlined above. It is recognized that cooling trenches or other measures may need to be in the groundwater table to assist in cooling surface discharge.

To verify that there will be no negative impact to the thermal regime of Blair Creek, the preliminary SWM designs should demonstrate the following:

- Based on a comparison of the pre- and post-development conditions, there should be no substantive change to the average daily stream temperature during the discharge period associated with the design conditions, including extended detention release (where ‘substantive’ is defined per MOE guidelines of less than 1˚ C change for coldwater systems).

- The SWM designs should demonstrate that proposed SWM ponds have the capacity to store the ‘25 mm followed by 12 mm storm 24 hours later’ back-to-back storms such that all release of surface discharge to the creek is passed through the cooling and/or infiltration facilities.
Attachment 3. Proposed Monitoring Framework

Blair Creek Thermal Regime - Monitoring Framework

Draft 2008/12/18 – Without Prejudice

Introduction

Blair Creek is a coldwater system that supports a self-sustaining Brook Trout population throughout the majority of the subwatershed. Considerable effort has gone into developing a means to quantify the thermal regime of the system as part of the ongoing Ontario Municipal Board mediation process. This has included development of a model to describe the annual variation of stream temperatures by Ecoplans Limited and analysis of thermal impacts of development scenarios by MTE. The process culminated in agreement on the existing conditions thermal regime based on statistical characteristics of measured data gathered and analyzed by the GRCA.

Quantifying the thermal regime of Blair Creek will aid future development in the subwatershed. The monitoring framework form the basis of monitoring plans developed in the preparation, review and approval of stormwater management (SWM) plans for proposed subdivisions within the Upper Blair Creek Drainage Study area in south Kitchener. It is intended that site-specific monitoring plans will be prepared as a condition of Draft Plan approval, to address any specific components of the SWM strategy for a given Draft Plan.

System and Site Monitoring

The Upper Blair Creek Functional Drainage Study (FDS) identifies a two tiered approach to monitoring, whereby “system” monitoring is undertaken by the GRCA and detailed site monitoring is carried out be development proponents. This approach has many merits, particularly since there are ten years of temperature data that have been collected by the GRCA and these data form the basis of defining existing conditions in Blair Creek. It is recommended that this approach be followed, and that the GRCA maintain the existing system monitoring network. Possible expansion of the ‘system’ monitoring could include the Roseville Swamp tributary at Reichert Drive as, well as the main branch at Reichert Drive.

A permanent weather station in the watershed should also be considered as part of the system monitoring. This station would provide all the data necessary for evaluating climate conditions in evaluating site data, and would provide a consistent base for all site specific monitoring. The station should collect air temperature, wind speed and direction, precipitation (rain and snow), and other parameters such incoming solar radiation could be considered for the data collection program. If a permanent weather station is not installed, the Preston AES Station or University of Waterloo Climate Station should be used.
Monitoring Requirements

The underlying premise of maintaining the thermal regime of Blair Creek is straightforward. If the major thermal inputs to the creek are maintained (primarily base flow temperatures and surface inflow temperatures), then the overall thermal regime of the system should not be altered as a result of stormwater management. In some cases, this operating principal could lead to enhancements, for example where increased base flow at cool temperatures could help reduce extreme temperatures in the stream.

This fairly simple premise leads to the foundation of the site-specific monitoring requirements. Because each development will have different site conditions and may propose a variety of thermal mitigation measures, the framework cannot attempt to cover all possibilities. However, the concepts are straightforward enough that they can be readily applied to most situations that may arise, with refinements added as necessary to address specific components of a given SWM strategy.

In the requirements set out below, continuous monitoring refers to monitoring by a remote data logger capable of capturing data at a minimum time increment of 30 minutes. A 30 minute time interval is generally adequate for data capture for the type of analyses we anticipate. However, shorter periods can be considered if very quick responses are expected. Sampling times should be set to be on the hour, half hour or quarter hour, depending on the sampling frequency (hourly, 30 minutes or 15 minutes respectively).

Data should be downloaded from loggers on a monthly basis and reviewed to see if there are situations that could require detailed review and/or response. Details of the review and response approach are provided below.

Monitoring reports should be provided on an annual basis. These reports should include a review of the data collected, details of any situations requiring review and documentation of any remedial action or contingencies that were initiated, including copies of any agency correspondence related to these procedures, and digital copies of the data.

As is generally applied to development applications, there are three phases in the monitoring program: pre-construction; during construction; and post-construction.

Pre-Construction

Pre construction generally includes a two year period prior to initiation of construction activities for a development. The FDS recognizes that there may be situations in which proponents may wish to proceed sooner than the two year pre construction period.

The Pre-Construction monitoring plan is to be included with the Preliminary SWM Design submission.
It is recommended that the pre construction thermal monitoring program include the following components:

- **Continuous stream temperature monitoring** upstream and downstream of the potential thermal impact area of the development site.

- If there are **defined overland flows** to the stream, temperature monitoring should be carried out for these features. The size and flow characteristics of such features will dictate the type of monitoring that is feasible for the site. While continuous monitoring is preferable, intermittent features may not be amenable to such monitoring, and seasonal or spot monitoring may have to be used.

- **Groundwater levels and continuous temperature monitoring** should be undertaken.
  
  o The locations should be sited as close to the stream as is feasible, and should take into consideration the potential impact of groundwater mounding from infiltration facilities.
  
  o Additional monitoring wells should be considered to address impacts where groundwater mounding is an issue.

- In all cases, the **stream flow data** should be collected with the temperature data. These data can be collected continuously or seasonally, depending on the requirements of the water quantity monitoring program. Sufficient flow data should be collected to enable thermal balance calculations. This can be done through correlation of spot measurements with the system wide continuous data, or by collecting continuous data on a site specific basis.

- The existing data logger network will be reviewed and finalized as a condition of Draft Plan approval.

- **Biological monitoring.** Benthic community sampling and fall Brook Trout spawning surveys are recommended, to be used as a qualitative measure of long-term trends in the system.

**During-Construction**

During construction monitoring is a continuation of the pre-construction program. Additional monitoring should be undertaken to document the operation of constructed facilities. This monitoring is in addition to any requirements that are part of the erosion and sediment control plan for the site.

The requirements will vary with the type of facility. For example, SWM pond monitoring should include continuous monitoring pond temperature prior to entering any cooling facility, preferably just below the pond surface and just above the pond bottom. The outlet temperature from any cooling facility prior to release to the stream should be monitored, as should release rates to the stream.
Depending on the locations of infiltration facilities, groundwater monitoring sites in addition to the identified in the pre construction period may be required. At a minimum, the pre construction monitoring should be continued to quantify groundwater temperatures and levels as close as is feasible to the discharge area to the stream.

It is recommended that the benthic and fisheries (Brook Trout spawning) surveying components be re-evaluated at this stage, to determine whether to continue, discontinue or modify the program.

The During-Construction monitoring plan is to be included with the Final SWM Design submission.

**Post-Construction**

The post-construction monitoring can be defined as the two year period after substantial completion of construction. For example, the City of Kitchener has recently recommended 2 years of monitoring after 95% of building permits have been issued. This monitoring allows evaluation of the performance of the installed facilities and confirmation that the system wide performance objectives have been met.

Usually this will involve a continuation of the during-construction monitoring, since all built facilities will have had a monitoring program initiated.

The Post-Construction monitoring plan is to be included with the Final SWM Design submission.

**Monitoring Evaluation**

The evaluation of monitoring data is an essential part of determining if operation targets have been met and if there is any impact on the system wide performance objectives. In order to provide perspective for monitoring data, the monthly total precipitation and average air temperature should be tracked and compared to the climate normal values. This will aid in interpreting monitoring data by indicating where the current year lies relative to normal conditions. For climate normals, the Preston climate station should be used. Data for this station can be found at [http://www.climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?Province=ONT%20&StationName=&SearchType=&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=4810&](http://www.climate.weatheroffice.ec.gc.ca/climate_normals/results_e.html?Province=ONT%20&StationName=&SearchType=&LocateBy=Province&Proximity=25&ProximityFrom=City&StationNumber=&IDType=MSC&CityName=&ParkName=&LatitudeDegrees=&LatitudeMinutes=&LongitudeDegrees=&LongitudeMinutes=&NormalsClass=A&SelNormals=&StnId=4810&).

Evaluation of monitoring data should focus on site-specific measures that could influence the thermal regime, and where there is some ability to implement contingency plans if required. The temperature of water released from cooling facilities should be compared with monthly average air temperatures. If significant variations are observed, the degree to which there is variation form the climate normals should be evaluated. If there are significant variations, evaluation cooling
effectiveness could be modified by comparing to average daily air temperatures in the monitoring
month, or in extreme conditions, even the week in which variations were observed.

Groundwater

Groundwater temperatures should be compared to data collected from the pre-development
monitoring program. Because there will not generally be a long period of record, this comparison
should be somewhat subjective and ensure that observed groundwater temperatures are in general
agreement with earlier monitoring data, subject to possible influence from variations from normal
conditions.

Instream Temperatures

Stream temperatures should be compared to the average conditions set out in the definition of the
existing thermal regime, and recognizing the variability of monthly means. If there are deviations
from the monthly averages, these variations should be interpreted in the context of the variation
of other climate data (air temperature and precipitation) from the climate normals.

Biological Measures

The focus of the monitoring programme is on the surface water and groundwater parameters that
directly support the stream habitat conditions. However, monitoring of two representative
ecological parameters, specifically macrobenthic communities and Brook Trout spawning
activity, is also proposed as a secondary or supplementary monitoring tool to the primary water-
based monitoring. The intent of this monitoring is to verify that these features are continuing to
function as expected, and to identify any unanticipated changes that warrant initiation of further
investigation.

Given the dynamic nature of aquatic systems, which respond to changes both with time and in
response to a variety of other natural and anthropogenic factors (e.g., climatic, beaver activity,
disease, fire, predation, water taking, angling, drainage changes), ecological monitoring is most
useful over time as sufficient information becomes available to enable reasonable identification of
trends. Therefore, while identification of relationships between the ecological and water resource
data becomes more reliable with time, it is important to recognize that it may still be difficult to
clearly identify potential cause and effect relationships.

Response

Site specific monitoring plans should identify the steps that will be followed if the data indicate
that there are variations from the existing thermal regime. For example, if cooling facilities are
not achieving sufficient cooling, contingency plans should be identified, and the procedure for
implementation clearly indicated.
Attachment 4. Proposed Conditions Temperature Impact Assessment – Duration Impacts (MTE)
Draft Technical Memo
Proposed Conditions Temperature Impact Assessment - Duration Impacts
Without Prejudice

The purpose of this Technical Memo is to provide some additional insight into the anticipated temperature impacts associated with proposed development in the Upper Blair Creek. This memorandum builds on the temperature impact assessment completed by MTE Consultants Inc. as documented in the Technical Memo entitled “Proposed Conditions Temperature Impact Assessment” (dated November 11, 2008).

Through recent discussions with Ecoplans and GRCA, it became apparent that further documentation and analysis surrounding the potential impacts of extending the duration of runoff using SWM infrastructure was required. The analysis described below addresses the extended duration by utilizing some of the results of the hydrologic modeling (GAWSER) that was completed as part of the previous Technical Memo.

A post-development to pre-development comparison of potential stream temperature increases was completed for the 25 mm summer design storm event using the following methodology.

- The pre and post-development surface runoff volumes were obtained for the areas upstream of New Dundee Road for each of the 4 days following the storm event.
- The total pre and post development streamflow volumes were obtained for New Dundee Road for each of the 4 days following the storm event.
- The pre-development storm event temperature increase associated with surface runoff was determined for each individual day, assuming a runoff temperature of 19.2 °C (normal summer runoff temperature), which is 2.7 °C above the assumed summer mean stream temperature of 16.5 °C.
- The post-development storm event temperature increase associated with surface runoff was determined for each individual day, assuming a surface runoff temperature of 19.2 °C and cooling trench runoff temperatures of 19.2 °C (Case 1) and 21.0 °C (Case 2), which are 2.7 °C and 4.5 °C above the assumed summer mean stream temperature of 16.5 °C respectively.

The calculations have been attached to this memo. As noted above, two post-development scenarios were completed, one assuming a cooling trench runoff temperature of 19.2 °C, and the second assuming a cooling trench runoff temperature of 21 °C. The cooling trench temperature of 19.2 °C represents the average runoff temperature during normal (average) climatic conditions, while 21.0 °C
represents the maximum runoff temperature during normal (average) conditions.  The results of the analysis are summarized in Tables 1 and 2.

Table 1 – Summary of Daily Temperature Increases with Surface Runoff – Pre-development

<table>
<thead>
<tr>
<th>Day</th>
<th>Surface Vol. (m³)</th>
<th>Total Vol. (m³)</th>
<th>Temp. Change (°C)</th>
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<tr>
<td>1</td>
<td>481</td>
<td>1732</td>
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<tr>
<td>2</td>
<td>281</td>
<td>1107</td>
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<td>3</td>
<td>289</td>
<td>1010</td>
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<tr>
<td>4</td>
<td>241</td>
<td>866</td>
<td>0.75</td>
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Table 2 – Summary of Daily Temperature Increases with Surface Runoff – Post-development

<table>
<thead>
<tr>
<th>Day</th>
<th>Surface Vol. (m³)</th>
<th>Total Vol. (m³)</th>
<th>Case 1 Temp. Change (°C)</th>
<th>Case 2 Temp. Change (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>247</td>
<td>1137</td>
<td>0.59</td>
<td>0.74</td>
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<tr>
<td>2</td>
<td>396</td>
<td>1928</td>
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<td>3</td>
<td>346</td>
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<td>0.84</td>
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<tr>
<td>4</td>
<td>247</td>
<td>1137</td>
<td>0.59</td>
<td>0.60</td>
</tr>
</tbody>
</table>

The results of the analysis indicate that there will not be a significant change to the in-stream temperature between pre and post development conditions over the duration of the surface runoff condition (4 days). Table 3 summarizes the daily differences versus pre-development conditions.

Table 3 – Daily difference between changes to stream temperature from runoff

<table>
<thead>
<tr>
<th>Day</th>
<th>Case 1 Post vs. Pre (°C)</th>
<th>Case 2 Post vs. Pre (°C)</th>
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<tr>
<td>1</td>
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<td>2</td>
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<tr>
<td>3</td>
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<td>0.07</td>
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<td>4</td>
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<td>-0.15</td>
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<tr>
<td>Average</td>
<td>-0.17</td>
<td>0.02</td>
</tr>
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</table>
CONFIRMED

* 3 redds
* 2 adult brook trout on redds
* 1 potential scrape/possible spawning activity
* No fish observed during 2008 surveys

2 potential scrapes/possible spawning activity
* No fish observed during 2008 surveys

1 potential scrape/possible spawning activity
* No fish observed during 2008 surveys

1 potential scrape/possible spawning activity
* No fish observed during 2008 surveys

DOON SOUTH KITCHENER
General Channel Characteristics & Fall 2008 Spawning Survey Results
Upper Blair Creek Functional Drainage Study
Mass Balance Temperature Analysis

### Blair Creek at New Dundee Road

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total peak flow (25 mm) storm (m$^3$/s)</td>
<td>0.065</td>
<td>0.034</td>
<td>0.054</td>
<td>0.055</td>
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<tr>
<td>Total runoff volume (m$^3$)</td>
<td>3.512</td>
<td>2.077</td>
<td>2.324</td>
<td>2.620</td>
</tr>
<tr>
<td>Base flow (m$^3$/s)</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
<td>0.004</td>
</tr>
<tr>
<td>Peak surface runoff flow (m$^3$/s)</td>
<td>0.061</td>
<td>0.030</td>
<td>0.050</td>
<td>0.051</td>
</tr>
<tr>
<td>Base flow temperature (°C)</td>
<td>17.5</td>
<td>17.5</td>
<td>17.5</td>
<td>17.5</td>
</tr>
<tr>
<td>Surface flow temperature (°C)</td>
<td>20.4</td>
<td>20.4</td>
<td>20.4</td>
<td>20.4</td>
</tr>
<tr>
<td>Average temperature during storm event (°C)</td>
<td>20.2</td>
<td>20.1</td>
<td>20.2</td>
<td>20.2</td>
</tr>
</tbody>
</table>

### Blair Creek at Dickie Settlement Road

<table>
<thead>
<tr>
<th></th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total peak flow (25 mm) storm (m$^3$/s)</td>
<td>0.384</td>
<td>0.318</td>
<td>0.347</td>
<td>0.347</td>
</tr>
<tr>
<td>Total runoff volume (m$^3$)</td>
<td>43.056</td>
<td>39.837</td>
<td>40.373</td>
<td>40.776</td>
</tr>
<tr>
<td>Base flow (m$^3$/s)</td>
<td>0.140</td>
<td>0.140</td>
<td>0.140</td>
<td>0.140</td>
</tr>
<tr>
<td>Peak surface runoff flow (m$^3$/s)</td>
<td>0.244</td>
<td>0.178</td>
<td>0.207</td>
<td>0.207</td>
</tr>
<tr>
<td>Base flow temperature (°C)</td>
<td>15.8</td>
<td>15.8</td>
<td>15.8</td>
<td>15.8</td>
</tr>
<tr>
<td>Surface flow temperature (°C)</td>
<td>20.4</td>
<td>20.4</td>
<td>20.4</td>
<td>20.4</td>
</tr>
<tr>
<td>Average temperature during storm event (°C)</td>
<td>18.7</td>
<td>18.4</td>
<td>18.5</td>
<td>18.5</td>
</tr>
</tbody>
</table>

Notes:
1. Base flows based on GRCA (Grand River Conservation Authority) flow gauge data
2. Peak Flows from GAWSER modelling
3. Base flow temperatures assumed as mean July stream temperatures using GRCA temperature data
4. Runoff temperatures from agricultural lands based on average July air temperature under normal climate conditions
5. Runoff temperatures from cooling trenches based on design calculations

Average temperature during storm events based on the following equation:

\[
\text{Average temperature} = \frac{Q_{\text{baseflow}} \times T_{\text{baseflow}} + Q_{\text{runoff}} \times T_{\text{runoff}}}{Q_{\text{total}}}
\]
APPENDIX E

Fluvial Geomorphology

Erosion Assessment - Blair Creek, Parish (October, 2005)

Erosion Thresholds Review and Update, Final Report, Parish (January, 2009)
Report to: Stantec Consulting Limited
49 Frederick Street
Kitchener, ON
N2H 6M7

Attention: Steve Brown, P.Eng

From: John Parish, M.A., P.Geo.

Report No.: 01-08-35
13 Pages, 1 Appendix

Date: January 2009
INTRODUCTION

Sections of the upper portion of the Blair Creek subwatershed have been identified for future urban development. To understand and minimize the potential effects of urban development, various studies have been undertaken. PARISH Geomorphic Ltd. was retained to update the previously completed threshold study, *Erosion Assessment Blair Creek, 2005*, for the lower portion of Blair Creek. The updated results would then be integrated with hydraulic modeling to provide additional interpretation on the erosion values, channel sensitivity and implications to the proposed land use.

In order to achieve this objective, the following tasks were undertaken:

- Confirm the threshold work that had been previously completed, including proving method/guidance on how the 0.320m³/s D50 threshold was determined.
- Sites/reaches that have been previously evaluated would be walked to confirm field setting and physical constraints.
- Stream reaches upstream of Highway 401 would be assessed.
- Update the background on channel dynamics (current aerial photography; flow records) to provide some insight on the recent channel adjustments observed in the monitoring work.
- Review the ‘new’ hydraulic model as well as information and reports regarding the proposed development and other OMB information related to the ‘erosion’ issue, including insight on the existing conditions.
- The methods and results would be summarized in a detailed report.

BACKGROUND REVIEW

Blair Creek is a tributary of the Grand River located in Cambridge and Kitchener, Ontario. The creek is situated in recent gravel/sand/silt stream deposits and peat/muck, surrounded by kame deposits, outwash, and lacustrine sand. The site location is illustrated in Figure 1.
In November 2003, detailed fieldwork was completed upstream of Old Mill Road to enable the quantification of erosion thresholds for the PARISH report entitled *Geomorphic Thresholds for Instream Flow Requirements*. At ten transects, the channel dimensions were measured and the substrate and bank characteristics assessed. Three of the ten cross-section sites were set-up for long-term monitoring. In August 2005, additional fieldwork was undertaken to provide an updated erosion assessment of Blair Creek. Two of the three monitoring cross-sections (Transects 1 and 3) were set-up in 2003 and they were re-measured in August, 2005. The third monitoring cross-section, located downstream of the pedestrian bridge could not be relocated and it was assumed buried. The August 2005 report confirmed that the 2003 erosion thresholds were appropriate. From 2006 to 2008, PARISH Geomorphic was retained by the Grand River Conservation Authority to continue and update the geomorphic monitoring program established in November 2003. Based on the 5-year monitoring period an insight of the degree of erosion could be evaluated.
MONITORING SUMMARY

In the 2005 PARISH report, it was determined that the site upstream of Old Mill Road and the site upstream of the golf course at Dickie Settlement Road were the two most sensitive reaches from a geomorphic perspective (ie. the most sensitive to changes in flow or sediment regime). In 2008, these sites were re-visited to confirm the results from 2005 and compared to the new data from the walks upstream of Highway 401. Based on qualitative observations, these two sites remain to be the most geomorphically sensitive in the study area. Both reaches were moderately sinuous, with low gradient and low entrenchment. Bank material was comprised of silt, fine sands and organics. The substrate within the pools consisted mainly of mixed sand, whereas riffle substrate was made up of cobble and gravel. The two sites included strong evidence of aggradation and widening in addition to indicators of planimetric form adjustment processes. Evidence of aggradation observed in the reaches included the presence of lobate and medial bars, and coarse materials embedded in riffles. Many signs of channel widening were also noted, such as falling and leaning trees, the presence of large organic debris, basal scour throughout more than 50% of the reach, and fracture lines along the top of bank.

Since the reaches upstream of Highway 401 did not show significant signs of instability, it was determined that fieldwork was not warranted in these sections. It was felt that the Old Mill Road site was a representative site of the area featuring high channel sensitivity.

In addition to the visit of the previously surveyed sites, re-monitoring of transects was conducted to gain further insight of channel processes in the area. In 2003, two monitoring cross-sections were established upstream of Old Mill Road. These sites have been regularly monitored since 2006. Based on the degree of change, the monitoring frequency was increased in 2008 (Figure 2).

Transect 1 continues to have a change in its bed profile (Figure 2). The channel bed is going through a fill and scour cycle based on the 5 year monitoring period. From 2003 to 2007, the left bank (north) had eroded or slumped. This may have been due to a single or series of high flow events or due to local condition of the site. Sediment samples were also
collected at the site in 2008. The sediment sampling results at transect 1 show a relatively consistent distribution of sediment sizes. As the substrate at this site is mainly sand this is to be expected. Results to date, combined with the cross-section adjustments and visual observations confirm that the sandy substrate at this location are continuously re-worked and re-organized as some material is flushed out of the site and new material migrates into the cross-section. Although in the past year there seems to be an accumulation of larger particles potentially being caught in the watercress re-growth. This trend will require additional monitoring to confirm whether it is episodic or a long term, continuous adjustment.

Transect 2 had displayed much less adjustment than the nearby Transect 1 from 2003 to 2008 (Figure 2). The channel bed was generally stable with some minor sediment accumulation on the right side of the channel, which is offset by some minor scour at the left side. There appears to be some sediment dispersion on the floodplain of both banks. Some minor toe erosion was also noted, which may be the result of cross-sectional widening. Due to the coarser nature of the substrate at this location this mode of adjustment is expected. Future monitoring would be required to confirm this observation and to establish any trends. Located upstream of Transect 1 this cross-section is immediately upstream of the backwater from the structural grade control of the Old Mill Road culvert. As a result the substrate distribution is more dynamic from a one year to the next. The site has a coarse armour layer consisting of gravels and cobbles with a transient layer of sand that fluctuates in volume and extent. Based on the 2008 sediment sample results, which show a distinct decrease in size, it appears that there has been a recent accumulation of the fine sediments at this location. This sediment appears to be an accumulation in the re-growth of bank vegetation of the fine substrate being lost from further up stream. This is more amplified than the filling and flushing pattern that has been observed since 2003.

Two additional transects were also established upstream and downstream of Dickie Settlement Road in 2006 and were re-surveyed in 2007 and 2008. Based on the two-years monitoring period, the transect downstream of Dickie Settlement Road was generally stable, with minor bed fluctuations and some toe erosion of the banks were observed. The transect upstream of Dickie Settlement Road indicated significant adjustment between 2006 to 2008.
The banks (left bank dominantly) were continuously losing bank material and the bed was losing material at the center of the channel.

Based on a review of the data, it appears as though a seasonal fluctuation in fine materials may occur within the channel, as fines are flushed through the system during spring freshet. That being said, the monitoring data does indicate a continual cycle of filling and deepening of the cross-section, with a fairly consistent overall trend towards increasing cross-sectional area. However, future monitoring would be warranted to assess changes caused by localized conditions or a long-term continuous trend towards adjustment.
EROSION THRESHOLDS

The collection of detailed field information is pertinent to modeling erosion thresholds. The calculations inherent in these models determine the threshold discharge for bed materials based on formulas for permissible velocity and critical shear stress. Selection of appropriate thresholds was, in part, dictated by indicators of active processes (e.g. widening or entrenchment), and channel substrate. Critical discharge calculations indicate the minimum flows that is necessary to initiate sediment entrainment and transport. If these or larger flows are sustained for a prolonged period of time, then excessive erosion could occur.

Based on the 2003 fieldwork, the erosion threshold was calculated to be 0.32 m$^3$/s, and this value was carried forward in the FDS report. As part of this work, this threshold value was re-visited. This was done, in part due to the monitoring work, which had shown erosion and fining of the bed material, suggesting that the 0.32 m$^3$/s threshold may be too high. In
addition, the work previously completed to support the 0.32 m³/s threshold was reviewed for the benefit of the landowners.

The 0.32 m³/s thresholds represents the flow that would mobilize the median (D50) substrate size and was determined based on data from two typical cross-sections (Transects 2 and 4) and the Dunn (1959) model, which takes into account the percentage of fines (silt and clay range) present within the bed materials. A critical discharge is then back-calculated based on the associated critical shear stress. A threshold for the D84 also used two typical cross-sections (Transects 3 and 4) but was calculated based on Komar (1987) to reflect the coarser underlying substrate. A detailed summary of the parameters used to develop the bed mobilizing thresholds has been provided in Appendix A.

Based on a close review of the monitoring results (see Figure 2), while there had been a trend towards channel erosion (increase in cross-sectional area), and finer substrate, that trend was reversed with the results from 2008. It appears that Blair Creek is experiencing 'scour and fill' tendencies, which is normal in alluvial channels. Given this dynamic characteristic, it was felt that the 0.32 m³/s was appropriate. That being said, it was felt that a sensitivity test was in order given the variability at the site and the relatively low threshold value. Given that the erosion threshold could be driven by either a critical shear stress of permissible velocity, the flow depth in the channel cross-section was increased one centimeter at a time. With each iterative flow depth, the corresponding width, velocity and discharge were calculated. The results indicated that erosion threshold could be increased to 0.400 m³/s. This was based on relatively minor changes to depth and flow velocity. Beyond this level, another centimeter of flow depth produced more dramatic increases in velocity and discharge.

### UPSTREAM CHANNEL CONDITIONS

With confidence in the channel characteristics and erosion thresholds for the downstream areas, it was pertinent that the upstream channel conditions be reviewed. Field reconnaissance of the upstream sections (essentially north of Highway 401) was completed on May 27, 2008. The channel in the upper sections was much smaller in width and area than the downstream reaches. The channels were also highly vegetated and generally lacked strong definition. It was concluded that while, these channels were stable, they would be
difficult to completed traditional detailed field studies. That being said, given the relatively small scale, they may be sensitive to changes in flow regime from the proposed development. As such, it was felt that the upstream areas be included in the modeling. Determination of an erosion threshold would follow the MOE simplified approach. The simplified approach essentially involves matching the exceedance of a flow that is 60% of the bankfull flow (2-year flow).

**HYDRAULIC MODELING REVIEW**

In order to facilitate the preferred stormwater management scenario for the proposed development, two scenarios (models) were examined and compared to the erosion threshold values developed in the 2005 PARISH report and confirmed in this report. Specifically, two models (Scenario 2 and 3) were run and their results were individually summed up in terms of change in the number of hours of exceedence/year and volume for six datasets (1976, 1985, 1986, 1987, 1988 and 1989). Scenario 2 was the model used in the 2007 Functional Drainage Study and Scenario 3 is the proposed MTE model carried out through the revised Functional Drainage Study in which it contains an increase in detention storage time to 96 hours.

The Hydrologic modeling of pre-post development flows were run for two sites in the Upper Blair Creek Study area, Old Mill Road and New Dundee Road. An update of the model was provided, which had re-run the post development flow model with some ‘routing’ improvement for both the New Dundee and the Old Mill Road site. The conclusion derived from this modeling was that, there was an increase in the total number of hours of flow above the erosion threshold; however, the actual total volume of flow above the threshold was less. While this was not an ideal result, having more hours above the threshold is better than more volume. The effect on Blair Creek would likely be seen as extended baseflow.

In order to improve these results, a final updated model was run for the New Dundee and Old Mill site. The results from the New Dundee station were provided for scenarios 2 and 3. Both sets of findings indicated that while the proposed conditions produce volumes
above the erosion threshold, these values are still below the current conditions. The total number of hours above the threshold value is also below the existing conditions. The results from the Old Mill station were also provided in the form of the two Scenarios: Scenario 3 (OMB model) and Scenario 2 (FDS model). In most cases, proposed conditions through Scenario 3 produced volumes below the current conditions, except for 1986, which indicated 30% more flow volume above the erosion threshold, compared with the current conditions. In addition, the results for the proposed condition in 1987 go from 4% below, as compared to current conditions, to 3% above. The number of hours above the threshold value was high than the existing conditions in Scenario 3, ranging from 28% to 60% above the existing hours.

The results from Scenario 2, meanwhile, achieve a close match between current and proposed conditions with respect to both flow volumes and hours of exceedance. Regarding hours, every year modeled was within (+/-) 10% of existing conditions, with only 1986 and 1988 producing more hours in exceedence of the threshold. Results were similar for volume of flow where two years (1976 and 1985) showed the greatest change with 18.05% and 17.5% less volume above the threshold compared to current conditions. All of the other years modeled were within (+/-) 10%. Only 1986 produced more volume of flow above the threshold (0.80% increase in proposed compared with current).

Based on the aforementioned analyses, either modeling scenario produces results that are satisfactory from an erosion perspective. That being said, it is recommended that long-term monitoring be implemented and continued in order to determine whether this post-development flow regime will negatively affect the creek (area and dimensions, substrate sizes, bank erosion).

**MONITORING RECOMMENDATIONS**

Based on the erosion assessment work completed as part of the review of the effects of the proposed land use change, a more elaborate monitoring plan was recommended. The monitoring was warranted as the results of the hydraulic modeling indicated that while the volume of flow above the erosion threshold improved in the post-development condition, there was an increase in the number of hours above the erosion threshold.
The focus of most of the erosion work was based on monitoring sites near Old Mill Road. It is felt that additional sites close to Dickie Settlement Road, the east branch at New Dundee Road and a control site along the west branch would be beneficial. The monitoring should build upon the program described as part of the Functional Drainage Study, shown below.

- Fluvial geomorphology - Monitoring of the fluvial geomorphological characteristics of the system should be undertaken as per the recommendations of the Erosion Assessment brief (Parish, 2005). As such, this should include “regular measurement of the sediment load (at the location downstream of the Old Mill Road), as well as the re-measurement [of] established control points (including control cross-sections and erosion pins) on an annual basis”, increasing to a seasonal frequency if warranted by observed changes. Efforts should also be made to re-visit the sites following large rainfall events (i.e. those greater than 5-year return period).

- Visual observations of stability in the receiving watercourses should also be completed at the outlet points from end-of-pipe SWM facilities to ensure that any increase in discharge volumes or conversion to point discharge does not result in an erosive condition.

The specifics of the additional work are shown in Table 1. This should be completed at a minimum of three cross-sections at each location. In addition to the monumented long-profile, at least 8 erosion pins should be placed at each site. Given the existing substrate, bed chains or depth-of-disturbance rods should also be added.
Table 1: Blair Creek Fluvial Geomorphology Proposed Monitoring Program.

<table>
<thead>
<tr>
<th>Monitoring Parameter</th>
<th>Frequency</th>
<th>Monitoring Specifics</th>
<th>Targeted Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional Form and Area</td>
<td>Annually at the same time of year</td>
<td>Three top-of-bank benchmarked cross-sections will be installed at representative areas at each site.</td>
<td>- Cross-sectional area should not increase or decrease in excess of 20%</td>
</tr>
<tr>
<td></td>
<td>+ An additional visit immediately following a flow event in excess of a 5 year event</td>
<td>- Cross-sectional form should be maintained within accepted limits (visual comparison only)</td>
<td></td>
</tr>
<tr>
<td>Longitudinal Profile</td>
<td>Annually at the same time of year</td>
<td>A section of channel within each site (encompassing a minimum of 4 riffle-pool sequences) will be surveyed. The details of the survey will include tops, crests and ends of riffles, upper, middle and lower pool depths as well as any breaks in slope, etc.</td>
<td>- Inter-pool and energy gradients should not differ in excess of 5%</td>
</tr>
<tr>
<td></td>
<td>+ An additional visit immediately following a flow event in excess of a 5 year event</td>
<td>- riffle grades should not increase or decrease in slope more than 20%</td>
<td>- riffle crest elevations should not increase or decrease to the point of impacting upstream bedforms (visual analysis)</td>
</tr>
<tr>
<td>Substrate Composition</td>
<td>Annually at the same time of year</td>
<td>A pebble count at each monitoring cross-section would be completed annually. The results would be tabulated and a particle size distribution would be generated.</td>
<td>- Due to the dynamic nature of the channel substrate dimensional adjustment is anticipated</td>
</tr>
<tr>
<td></td>
<td>+ An additional visit immediately following a flow event in excess of a 5 year event</td>
<td>- As a performance threshold, adjustment in excess of an order of magnitude will act as a trigger</td>
<td></td>
</tr>
<tr>
<td>Substrate Stability</td>
<td>Annually at the same time of year</td>
<td>A bed-chain or depth of disturbance rod will be installed at each cross-section within each reach. The depth of bed disturbance will be measured on an annual basis.</td>
<td>- Degradation or aggradation of bed material in excess of 5cm annually at the bed-chain location will act as a trigger.</td>
</tr>
<tr>
<td></td>
<td>+ An additional visit immediately following a flow event in excess of a 5 year event</td>
<td>- Disturbance or reworking of the substrate in excess of 5cm (with minimal vertical adjustment in bed surface elevation) will be noted but will not be considered detrimental to channel stability</td>
<td></td>
</tr>
<tr>
<td>Lateral Migration</td>
<td>Annually at the same time of year</td>
<td>A series of erosion pins (approx 8 at each site) will be installed horizontally into the face of several banks in strategic locations including outside banks of pools and</td>
<td>- Annual migration rates exceeding 15cm per year in pools and 5cm per year in riffles will trigger an assessment of the channel conditions at the site.</td>
</tr>
<tr>
<td>Monitoring Parameter</td>
<td>Frequency</td>
<td>Monitoring Specifics</td>
<td>Targeted Thresholds</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------</td>
<td>---------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>of a 5 year event</td>
<td>other areas of anticipated erosion and in riffle areas where no erosion is expected (control). Rates of adjustment will be calculated on an annual basis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Performance</td>
<td>Annually at the same time of year</td>
<td>A series of photographs at each cross-section location will be included with the monitoring data package – does not supplant photographic records from other disciplines</td>
<td>No Threshold – information only</td>
</tr>
<tr>
<td>+ An additional visit immediately following a flow event in excess of a 5 year event</td>
<td></td>
<td></td>
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</table>

**SUMMARY**

The work completed as part of this erosion update study, essentially confirmed the appropriateness of the 0.320 m³/s threshold flow. Based on a sensitivity analysis, this flow was increased to 0.400 m³/s. This value, while derived from data from the Old Mill Road area, is representative of the conditions at Dickie Settlement Road. Based on the work, this increase would result in negligible change or risk to increased channel erosion. Upstream observations of the channels were completed, and based on the relative scale, a new erosion threshold (New Dundee Road) was included. A review of the continuous modeling results revealed that the proposed development would not likely have a detrimental impact to the receiving watercourses with respect to erosion. In most instances, the total volume of flow above the erosion threshold was less in the proposed condition than the existing condition. That being said, the duration of time of flow above the erosion threshold would be higher in the proposed condition. Essentially, these results described smaller peaks during an event hydrograph, but prolonged baseflow. While this scenario is not ideal, having an increase in hours to time was deemed to be better than an increase in flow volume. Given these results, a more extensive monitoring program was proposed.
REFERENCES


### Blair Creek Bed Mobilizing Threshold - D50

**Hydraulic Inputs:**

- **Energy Gradient:** 0.41%
- **Manning's 'n':** 0.033
- **Roughness Coeff. (ks):** 0.018626047
- **Shield's Theta:** 0.047
- **Critical Particle Size:** D50
- **Iteration Method:** average
- **% of bed width to be mobilized:** 50.0%
- **Initial Water Depth for Iterations (m):** 0.001
- **Use variable slope approach?** no

<table>
<thead>
<tr>
<th>Cross-section Name</th>
<th>XS-2</th>
<th>XS-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankfull Width (m)</td>
<td>5.82</td>
<td>3.98</td>
</tr>
<tr>
<td>Average Bankfull Depth (m)</td>
<td>0.38</td>
<td>0.50</td>
</tr>
<tr>
<td>Maximum Bankfull Depth (m)</td>
<td>0.78</td>
<td>0.76</td>
</tr>
<tr>
<td>Bankfull Width:Depth</td>
<td>15.22</td>
<td>7.94</td>
</tr>
<tr>
<td>Cross-sectional Area (m²)</td>
<td>2.29</td>
<td>2.00</td>
</tr>
<tr>
<td>Wetted Perimeter (m)</td>
<td>6.30</td>
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</tr>
<tr>
<td>Hydraulic Radius (m)</td>
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<tr>
<td>Left Bank Angle (°)</td>
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<td>19.3</td>
</tr>
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<td>Right Bank Angle (°)</td>
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<td>Left Bank Height (m)</td>
<td>0.19</td>
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<td>Right Bank Height (m)</td>
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<td>Left Bank Wetted Perimeter (m)</td>
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<td>Right Bank Wetted Perimeter (m)</td>
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<tbody>
<tr>
<td>Bankfull Discharge (m³/s)</td>
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<td>2.62</td>
</tr>
<tr>
<td>Average Bankfull Velocity (m/s)</td>
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</tr>
<tr>
<td>Maximum Bankfull Velocity (m/s)</td>
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<td>1.67</td>
</tr>
<tr>
<td>Average Shear Velocity [u*] (m/s)</td>
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<td>0.13</td>
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<td>5.50</td>
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<td>Reynolds Flow Type</td>
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<td>Froude Number</td>
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<td>Froude Flow Type</td>
<td>Sub-critical</td>
<td>Sub-critical</td>
</tr>
<tr>
<td>Stream Power (W/m)</td>
<td>114.64</td>
<td>105.47</td>
</tr>
<tr>
<td>Stream Power per unit Width (W/m²)</td>
<td>19.70</td>
<td>26.50</td>
</tr>
<tr>
<td>Average Shear Stress (N/m²)</td>
<td>14.64</td>
<td>17.16</td>
</tr>
<tr>
<td>Maximum Shear Stress (N/m²)</td>
<td>30.82</td>
<td>30.33</td>
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<tr>
<td>Left Bank Shear Stress (N/m²)</td>
<td>9.58</td>
<td>11.32</td>
</tr>
<tr>
<td>Right Bank Shear Stress (N/m²)</td>
<td>9.32</td>
<td>10.52</td>
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<tr>
<td>Critical Particle Diameter for Analysis - D50 (m)</td>
<td>0.00004</td>
<td>0.00007</td>
</tr>
<tr>
<td>% Silt-Clay</td>
<td>25.64</td>
<td>21.95</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cross-section Name</th>
<th>XS-2</th>
<th>XS-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Shear Stress - Dunn (1959)</td>
<td>6.11</td>
<td>5.11</td>
</tr>
<tr>
<td>Critical Discharge (m³/s)</td>
<td>0.38</td>
<td>0.27</td>
</tr>
<tr>
<td>Critical/Bankfull Discharge</td>
<td>13.30%</td>
<td>10.43%</td>
</tr>
<tr>
<td>Maximum Depth (m)</td>
<td>0.34</td>
<td>0.28</td>
</tr>
<tr>
<td>Average Depth (m)</td>
<td>0.20</td>
<td>0.18</td>
</tr>
<tr>
<td>Maximum Velocity</td>
<td>0.94</td>
<td>0.81</td>
</tr>
<tr>
<td>Average Velocity</td>
<td>0.60</td>
<td>0.53</td>
</tr>
</tbody>
</table>
Blair Creek Bed Mobilizing Threshold - D84

Hydraulic Inputs:

Energy Gradient 0.41%
Manning's 'n' 0.033
Roughness Coeff. (ks) 0.018626047
Shield's Theta 0.047
Critical Particle Size: d84
Iteration Method average
% of bed width to be mobilized 50.0%
Initial Water Depth for Iterations (m) 0.001
Use variable slope approach? no

Cross-section Name: XS-3 XS-4
Bankfull Width (m) 5.76 3.98
Average Bankfull Depth (m) 0.41 0.50
Maximum Bankfull Depth (m) 0.70 0.76
Bankfull Width:Depth 14.06 7.94
Cross-sectional Area (m2) 2.38 2.00
Wetted Perimeter (m) 6.30 4.69
Hydraulic Radius (m) 17.2 19.3
Left Bank Angle (o) 17.2 19.3
Right Bank Angle (o) 9.5 53.1
Left Bank Height (m) 0.31 0.14
Right Bank Height (m) 0.06 0.24
Left Bank Wetted Perimeter (m) 1.050878772 0.425472403
Right Bank Wetted Perimeter (m) 0.36502569 0.3

Cross-section Name: XS-3 XS-4
Bankfull Discharge (m3/s) 2.79 2.62
Average Bankfull Velocity (m/s) 0.97 1.10
Maximum Bankfull Velocity (m/s) 1.54 1.67
Average Shear Velocity [u*] (m/s) 0.12 0.13
Reynolds Number 1259.08 897.79
Reynolds Flow Type Rough Rough
Froude Number 0.49 0.50
Froude Flow Type Sub-critical Sub-critical
Stream Power (W/m) 112.38 105.47
Stream Power per unit Width (W/m2) 19.51 26.50
Average Shear Stress (N/m2) 15.16 17.16
Maximum Shear Stress (N/m2) 27.25 30.33
Left Bank Shear Stress (N/m2) 11.02 11.32
Right Bank Shear Stress (N/m2) 9.42 10.52
Critical Particle Diameter for Analysis - D84 (m) 0.01820 0.01220

Cross-section Name: XS-3 XS-4
Flow Compenancy - Komar/Gravel - (m/s) 0.75 0.62
Critical Discharge (m3/s) 1.46 0.72
Critical/Bankfull Discharge 52.18% 27.45%
Maximum Depth (m) 0.53 0.42
Average Depth (m) 0.32 0.28
Maximum Velocity 1.27 1.09
Average Velocity 0.84 0.74
EROSION ASSESSMENT
BLAIR CREEK

To: Grand River Conservation Authority
   400 Clyde Road
   PO Box 729
   Cambridge, Ontario
   N1R 5W6

Attention: Mr. Gus Rungis, P.Eng.

From: Lindsay Hilts B.A.Sc. and John Parish, P. Geo, M.A.

Subject: Erosion Assessment – Blair Creek

Date: October 5, 2005
INTRODUCTION

Portions of the upper part of the Blair Creek subwatershed are zoned for development. To minimize the effect of development, various studies have and are being completed. Included in this is a hydrology/hydraulics study to guide stormwater management decisions. To assist this process, a fluvial geomorphology component was added with the purpose to review and refine erosion thresholds derived for Blair Creek.

BACKGROUND

Blair Creek is a tributary of the Grand River located in Cambridge and Kitchener, Ontario. The creek is situated in recent gravel/sand/silt stream deposits and peat/muck, surrounded by kame deposits, outwash, and lacustrine sand. The site location is illustrated in Figure 1.

FIELD RECONNAISSANCE

Fieldwork has been completed on Blair Creek at two main locations, upstream of Old Mill Road (Reach A) and upstream of the golf course at Dickie Settlement Road (Reach B). The locations of the fieldwork sites are shown in Figure 2.
In November 2003, detailed fieldwork was completed on Reach A to enable the quantification of erosion thresholds for the PARISH report entitled Geomorphic Thresholds for Instream Flow Requirements. At ten transects, the channel dimensions were measured and the substrate and bank characteristics assessed. Three of the ten cross-section sites were set-up for long-term monitoring. The typical reach characteristics are summarized in Table 1.

**Table 1.** Typical reach characteristics of Blair Creek, Site A.

<table>
<thead>
<tr>
<th></th>
<th>Range</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankfull Width (m)</td>
<td>3.98-5.82</td>
<td>5.17</td>
</tr>
<tr>
<td>Bankfull Depth (m)</td>
<td>0.31-0.48</td>
<td>0.41</td>
</tr>
<tr>
<td>Bank Height (m)</td>
<td>0.45-12.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Bank Angle (degrees)</td>
<td>12.0-82.0</td>
<td>50.7</td>
</tr>
<tr>
<td>Bankfull Gradient (%)</td>
<td>-</td>
<td>0.22</td>
</tr>
<tr>
<td>$D_{50}$ (cm)</td>
<td>-</td>
<td>0.018</td>
</tr>
</tbody>
</table>
In August 2005, additional fieldwork was undertaken to provide an updated erosion assessment of Blair Creek. Two of the three monitoring cross-sections (Transects 1 and 3) set-up in 2003, were re-measured on August 17, 2005. The third monitoring cross-section, located downstream of the pedestrian bridge, could not be relocated and is assumed buried. The changes in cross-section measurements at the two monitoring sites are illustrated in Figures 3 and 4.

**Figure 3.** Bankfull cross-section at Transect 1.

**Figure 4.** Bankfull cross-section at Transect 3.
Since 2003, Transect 1 has undergone some aggradation, particularly in the thalweg and along the left side of the channel. In contrast, Transect 3 has undergone some minor bed erosion. Neither cross-section has substantially increased in width, indicating that bank erosion observed throughout the reach may no longer be prevalent. The degree of change observed in the cross-sections is not substantial enough to warrant revision of the erosion thresholds.

Based on field observations, it was determined that the reach upstream of Old Mill Road (Reach A) and the reach upstream of the golf course at Dickie Settlement Road (Reach B) are the two most geomorphically sensitive reaches (i.e. the most sensitive to changes in flow or sediment regime). Rapid assessments were conducted to quantify and compare the sensitivities of the reaches. Two rapid assessment techniques were employed: The Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT).

The Rapid Geomorphic Assessment was developed by the Ontario Ministry of Environment (1999) to assess reaches in mainly urban channels. RGA’s were undertaken for each reach and involved identifying indicators of instability, such as exposed tree roots, undercutting, presence of chutes, etc. The presence or absence of these indicators was identified in the following adjustment categories: aggradation, degradation, channel widening and planimetric form. Evidence of instability noted within each category was tallied and used to calculate a reach stability index, which corresponds to a stability classification (Table 2).

Table 2. Stability index values and corresponding stability classification for the RGA.

<table>
<thead>
<tr>
<th>Stability Index</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 0.20</td>
<td>Channel is in regime or stable</td>
</tr>
<tr>
<td>0.21 – 0.4</td>
<td>Channel is in a stressed or transitional state</td>
</tr>
<tr>
<td>&gt;0.40</td>
<td>Channel is in adjustment and evidence of instability is prevalent</td>
</tr>
</tbody>
</table>

The second assessment was the Rapid Stream Assessment Technique (Galli 1996) which involved a broader, qualitative assessment of the overall health of the reach. This included observations of channel stability, scour/deposition, instream habitat, water quality, riparian conditions and biological indicators, such as the abundance of benthic invertebrates. Each indicator was ranked numerically and the ranking scores were summed up, with lower values
indicating poorer stream health and a high value representing a rich and healthy stream (Table 3). Also included in the RSAT were general observations of channel dimensions, such as bankfull width and depth, substrate size, bank height, vegetation cover, channel hardening and other disturbances. Table 4 summarizes the rapid assessment scores and dominant geomorphic processes affecting each reach, while a photographic record of the reaches is presented in Appendix A.

Table 3. RSAT scores and corresponding stream quality classifications.

<table>
<thead>
<tr>
<th>Score</th>
<th>Stream Quality Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 35</td>
<td>HIGH</td>
</tr>
<tr>
<td>20 – 35</td>
<td>MODERATE</td>
</tr>
<tr>
<td>&lt; 20</td>
<td>LOW</td>
</tr>
</tbody>
</table>

Table 4. Rapid geomorphic assessment scores.

<table>
<thead>
<tr>
<th>REACH</th>
<th>RGA SCORE</th>
<th>RSAT SCORE</th>
<th>DOMINANT PROCESS(ES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upstream of Old Mill Road</td>
<td>0.5</td>
<td>31.5</td>
<td>Aggradation/Widening</td>
</tr>
<tr>
<td>Upstream of Golf Course at Dickie Settlement Road</td>
<td>0.5</td>
<td>32</td>
<td>Widening/Aggradation</td>
</tr>
</tbody>
</table>

The observations made during the rapid assessments confirmed that the two reaches exhibit many physical and geomorphic similarities. Both reaches were moderately sinuous, with low gradient and low entrenchment. Bank material was comprised of silt, fine sands and organics. The substrate within the pools consisted mainly of mixed sand, whereas riffle substrate was made up of cobble and gravel. At Reach A, bankfull width and depth were estimated to be 5 to 15m and 0.5 to 1.5m, respectively. At Reach B, bankfull widths ranged from 7 to 20 metres, while bankfull depths ranged from 0.3 to 0.8m.

Geomorphic similarities between the two reaches included the strong evidence of aggradation and widening in addition to indicators of planimetric form adjustment processes. Evidence of aggradation observed in the reaches included the presence of lobate and medial bars, and coarse materials embedded in riffles. Many signs of channel widening were also noted, such as falling and leaning trees, the presence of large organic debris, basal scour
throughout more than 50% of the reach, and fracture lines along the top of bank. The formation of chutes, cut-off channels and islands was also observed at both locations.

Based on the rapid geomorphic assessments, both reaches were classified as “In Adjustment” with “Moderate Stability”. Taking into account the geomorphic and physical likeness of the reaches, as well as the rapid assessment scores, it can be concluded that the reaches are of equal geomorphic sensitivity. Thus, the Reach A can be considered representative of the most sensitive channel conditions. Accordingly, erosion thresholds derived for Reach A in the 2003 geomorphic thresholds report can be applied to both sites.

**EROSION THRESHOLDS**

Based on the 2003 fieldwork, the low flow erosion threshold, the $D_{50}$ bed mobilizing threshold, and the $D_{84}$ bed mobilizing threshold were calculated for Reach A. The low flow threshold (also called the residual pool threshold) simulates the point at which water levels are sufficiently low to isolate the pools. This is accomplished by identifying the ‘residual pool depth’ for each site. Residual pool depth is defined as the difference in depth between a pool and the downstream riffle crest (Lisle, 1987). The low flow threshold describes flow conditions in which the system nears the limit of hydraulic connectivity between pools, however, it may be well below that where biologically connectivity is maintained. Within Reach A, aggradation was the dominant process. The generally poorly-defined low flow channel form, particularly in the riffles, was indicative of this process. With this in mind, separate low flow thresholds were developed based on the average low flow channel dimensions as well as a typical riffle transect. The low flow thresholds calculated for the average cross-section and the typical cross-section are 0.69 m$^3$/s and 0.15 m$^3$/s, respectively.

The $D_{50}$ bed mobilizing threshold was calculated to be 0.32 m$^3$/s, while the $D_{84}$ bed mobilizing threshold was calculated to be 1.19 m$^3$/s. These critical threshold discharges correspond to the minimum flows required to initiate sediment movement. As such, it can be presumed that, at a discharge of 0.32 m$^3$/s, 50% of the bed materials have the potential to become entrained. Similarly, at a discharge of 1.19 m$^3$/s, there is the potential for movement of 84% of the bed material. Since these discharges correlate exclusively to the potential for sediment entrainment, they do not necessarily represent the flow rates at which erosion occurs. However, it is reasonable to assume that the sustained occurrence of the $D_{50}$
threshold discharge or larger flows over a prolonged period of time could cause excessive erosion.

The results of the rapid geomorphic assessments indicate that the erosion thresholds calculated for the Reach A are representative of the most sensitive sections of the channel and thus are applicable to the Reach B as well. The thresholds provided for Blair Creek are inherently conservative not only because they are based on the potential initiation of sediment entrainment, but also because they reflect conditions along the site which exhibits the greatest sensitivity to altered sediment and flow regimes.

Additionally, Blair Creek has been impacted by several large flow events in recent years that have likely initiated geomorphic adjustments. It is believed that the creek has experienced significant aggradation due to these storm events and that the $D_{50}$ erosion threshold estimates reflect the entrainment of fine material which has been deposited on top of the coarser parent material. Entrainment of the parent material would likely occur at greater threshold values, somewhat closer to the $D_{84}$ values.

The low flow values calculated for Blair Creek in the Geomorphic Thresholds for Instream Flow Requirements report suggest that flows greater than the calculated $D_{50}$ threshold value may actually occur regularly within the creek. The low flow threshold calculated based on a typical transect was 0.15 m$^3$/s, however, the threshold using the average low flow channel dimension (0.69 m$^3$/s) was more than twice the $D_{50}$ erosion threshold. Another indication of the conservative nature of the thresholds is that at the time of the field investigation, no turbidity was observed despite a flow rate of approximately 1.43 m$^3$/s.

**HYDROLOGY**

Hydrologic modelling of pre- and post-development flows was completed by Stantec Ltd., with results summarized in the Upper Blair Creek (Kitchener) Functional Drainage Study (Draft Report). Hydrographs as well as plots of depth and velocity versus time for five major storm events were also provided to Parish Geomorphic for analysis.

The Upper Blair Creek (Kitchener) Functional Drainage Study compares the preferred stormwater management scenario for the proposed development to the existing conditions
and a previously approved alternative in terms of change in the number of hours of exceedence per year. Table 5 summarizes these results for erosion thresholds corresponding to the D_{50} and D_{84} particle sizes.

### Table 5. Comparison of Erosion Threshold Exceedences

<table>
<thead>
<tr>
<th>EROSION THRESHOLD FLOW (M3/S)</th>
<th>DURATION ABOVE EROSION THRESHOLD FLOW (HRS/YR)</th>
<th>DIFFERENCE VS. EXISTING SCENARIO (HRS/YR)</th>
<th>DIFFERENCE VS. APPROVED SCENARIO (HRS/YR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>45</td>
<td>-4</td>
<td>-5</td>
</tr>
<tr>
<td>0.9</td>
<td>107</td>
<td>4</td>
<td>-2</td>
</tr>
<tr>
<td>0.6</td>
<td>304</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>0.3</td>
<td>1555</td>
<td>459</td>
<td>349</td>
</tr>
</tbody>
</table>

This comparison clearly illustrates that the change in percent exceedence of the D_{84} threshold is negligible when compared to the existing conditions or the approved scenario, as the difference in less than 0.1%. The table also shows that the preferred scenario will result in discharges exceeding the D_{50} threshold an additional 5.24% of the year. When compared to the approved scenario, it is predicted that the proposed scenario will result in discharges greater than the D_{50} threshold value an additional 3.99% of the year.

The five hydrographs provided to Parish Geomorphic corresponded to three major storm events, a large melt event and an average melt event. The hydrographs illustrate discharge versus time for pre and post development flows at the Dickie Settlement Road flow gauging station. To gain a better understanding of the impact of the proposed flow regime alterations on the most sensitive reaches, the plots of depth and velocity versus time were generated for the Reach A monitoring cross-sections. Table 6 summarizes the maximum increase and percent increase in discharge, velocity and depth occurring during each of the modelled flow events. Although the area under the hydrograph curve increases from pre- to post- development for all five events, the maximum percent change in depth and velocity is generally low.
**Table 6. Summary of hydrologic modelling results**

<table>
<thead>
<tr>
<th>STORM EVENT</th>
<th>107MM OVER 7 HOURS</th>
<th>25.5MM OVER 5 HOURS</th>
<th>24.8MM OVER 2 HOURS</th>
<th>LARGE MELT EVENT</th>
<th>AVERAGE MELT EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Increase in Flow (m³/s)</td>
<td>0.148</td>
<td>0.062</td>
<td>0.032</td>
<td>0.085</td>
<td>0.086</td>
</tr>
<tr>
<td>Max. Increase in Flow (%)</td>
<td>29</td>
<td>17.0</td>
<td>19.5</td>
<td>26.2</td>
<td>29</td>
</tr>
<tr>
<td>Max. Increase in Depth (m)</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Max. Increase in Depth (%)</td>
<td>17</td>
<td>11</td>
<td>12</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Max. Increase in Velocity (m/s)</td>
<td>0.07</td>
<td>0.05</td>
<td>0.05</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Max. Increase in Velocity (%)</td>
<td>14</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>14</td>
</tr>
</tbody>
</table>

**INTEGRATED THRESHOLD ANALYSIS**

Higher flows in Blair Creek will result in an increase in sediment transport through the system. As recent storm events have caused the deposition of fine materials (mainly sands) on top of the coarser bed material, this layer of sand will provide a source for the increased sediment demand. The increased sediment transport will likely produce visibly higher turbidity levels during high flow events and may have an adverse effect the fish habitat within the stream. Despite the potential impacts of resuspending the sand veneer, it is believed that channel restoration or mitigation of sediment loading is not yet warranted. Analysis of the hydrologic modelling results and the conservative nature of the erosion thresholds indicate that the proposed scenario should be tolerated by the system without significant adverse impacts.

**MONITORING RECOMMENDATIONS**

Development within the Blair Creek subwatershed will likely be implemented in phases over a number of years. A monitoring program is recommended to ensure that channel is able to adapt to the increased flow rates without significant geomorphic adjustment. The recommended monitoring program involves regular measurement of the sediment load (at
the location downstream on Old Mill Road), as well as the re-measurement of established control points (including control cross-sections and erosion pins) on an annual basis. If pronounced change is observed, the frequency could be increased to a seasonal rate. Whatever the frequency, efforts should be made to re-visit the sites after a large flow event (>5 year return period). Most of the geomorphic field work represents only a ‘snap-shot’ of channel conditions. Based on the analysis from the field work, results are made and inferences drawn regarding channel processes. By undertaking a simple monitoring program, some of the uncertainty associated with channel processes is removed. The monitoring work provides frequent, ‘low-tech’ observations which, especially after higher flow events, enhance our understanding of a river system. Monitoring also enables direct measurements of channel change, such as bank erosion and bed scour, which can be linked with the historic assessment, to provide a clear picture of channel dynamics.

**SUMMARY**

In 2003 erosion thresholds were established for Blair Creek, Reach A. The D$_{50}$ erosion threshold and the D$_{84}$ erosion threshold were calculated to be 0.32m$^3$/s and 1.19m$^3$/s, respectively. Through additional fieldwork, it has been confirmed that these values are still appropriate due to the relative sensitivity of the site and the conservative nature of the erosion thresholds. Considering these factors, as well as the results of the hydrologic modelling, the proposed development scenario is unlikely to cause significant adverse impacts on the geomorphology of the creek.
REACH A

PHOTO 1. LOOKING UPSTREAM AT PEDESTRIAN BRIDGE

PHOTO 2. TYPICAL INSTREAM WOODY DEBRIS
PHOTO 3. BAR FORMATION AND BANK EROSION

PHOTO 4. LOOKING DOWNSTREAM AT TRANSECT 3
PHOTO 7. CULVERTS AT OLD MILL ROAD CROSSING AT DOWNSTREAM END OF REACH A

REACH B

PHOTO 8. MID CHANNEL ISLAND
PHOTO 9. TYPICAL WOODY DEBRIS IN CHANNEL

PHOTO 10. BANK EROSION AND VEGETATED BAR FORMATION
APPENDIX F

Regional Floodplain Mapping Update
F.1 Introduction & Background

The incorporation of peak flow control for the Regional storm event was proposed within drafts of the Upper Blair Functional Drainage Study (FDS) as a means of meeting the objectives of the Blair, Bechtel, and Bauman Creeks Subwatershed Plan (BBB Study)(1997) and the Terms of Reference for the FDS (Task 4). During the draft Study preparation and review process for the FDS, however, a number of questions and concerns were raised pertaining to the requirement for Regional Storm control, largely as a result of the impact that such controls have on SWM facility sizing. To address these concerns, additional work was undertaken to review and revise the existing conditions hydraulic model to reflect the extent of current structure information, and to evaluate the potential impacts associated with partial or full relaxation of the requirement for Regional Storm controls within the potentially developing areas (refer Appendix B).

The original hydraulic model (HEC-2) for Blair Creek was completed as part of the BBB Study, with peak flow rates as determined by the associated hydrologic modeling (GAWSER). The Grand River Conservation Authority (GRCA) converted the original HEC-2 model to the HEC-RAS model for use in the current study. Stantec updated this work using the most current information from the Upper Blair FDS, as discussed in more detail in Section F.1.2.

Based on discussions with the GRCA and review of the Technical Guide - River and Stream Systems: Flood Hazard Limit (OMNR – Water Resources Section, 2002) the selection of modeling approaches and floodline delineations should reflect the most conservative design assumptions. In this regard, the flowing criteria are applicable for floodplain modeling:

- Upstream flood lines are to reflect backwater effects caused by bridges and culverts (i.e. bridges and culverts should be included in the modeling)
- Downstream flood lines should ignore the effects of bridges and culverts (i.e. there should be no flow attenuation due to these structures)
- Stormwater management facilities may not be used to provide any reduction in flood flows
- Land use should be based on ultimate development conditions

F.1.1 UPDATING THE GAWSER HYDROLOGIC MODEL

The proposed development scenario from the FDS was defined as the “ultimate development conditions” in the determination of Regional peak flows in Blair Creek for hydraulic analysis. As per the criteria outlined previously, the following revisions were made to the hydrologic model for the purpose of floodplain mapping:

- All stormwater management controls were removed from the proposed conditions hydrologic model
For the purposes of determining downstream peak flows, all existing storage reservoirs along Blair Creek, such as the Old Mill Pond and those created by the road crossings of New Dundee Road and Highway 401, were removed.

For the purposes of determining the backwater characteristics upstream of the Highway 401 crossing and an associated rating curve for use in the hydraulic analysis, a second model was created to reflect the existing culvert and upstream storage characteristics.

F.1.2 UPDATING THE HYDRAULIC MODEL

A field visit was completed on May 8, 2006 to verify culvert and bridge dimensions used in the hydraulic model. Generally speaking, the structure characteristics noted in the field measurements compared well to the original hydraulic model except for the Blair Road Bridge, which was not defined in the original model. However, several changes to the original HEC-RAS model were required to reflect modeling approaches before flood levels were determined, as described below:

- Entrance loss coefficients for culverts and bridges were updated to reflect observed field data of culvert and bridge approach geometry.
- Bridge modeling approach for high flows was changed from standard step (energy approach) to pressure and/or weir flow in order to accurately model flooded bridge crossings.
- Additional flow change locations were added to the model to reflect the updated hydrologic model.
- The Blair Creek tributary draining Roseville Swamp was designated as a permanent ineffective flow area (cross section 6640) to reflect flood conditions.
- Highway 401 top of road elevations were updated to reflect City of Kitchener mapping. An additional 0.44 m was added to the road elevations to reflect the concrete median.
- Blair Road crossing was revised to reflect observed field data. As mentioned above, the original model included a roadway and a channel but no culvert or bridge.
- Flows from the proposed conditions hydrologic model were used in the HEC-RAS model in place of the original BBB study flows.

All other characteristics of the HEC-RAS model fell within acceptable parameter ranges and were not changed for the subsequent analysis.
F.1.3 OVERVIEW OF MODELING PROCEDURES

As introduced in Section F.1.2, adherence to the mapping criteria outlined in Section F.1 required something of an iterative approach involving the creation of two hydrologic and hydraulic models. The first set of models included the Highway 401 culvert crossing and upstream storage area in order to account for the backwater effects upstream of Highway 401 in the definition of floodline upstream of the crossing. The second set of models removed the Highway 401 crossing and associated storage to eliminate the effects of flow attenuation for locations downstream of the crossing. Stormwater management facilities and smaller road crossings with limited hydrologic or hydraulic impacts were removed from both sets of models. These models are discussed below:

- Hydrologic and hydraulic models with Highway 401 and associated upstream storage taken into consideration
  - Flow attenuation (storage) is included at Highway 401 in the hydrologic model
    - The storage-discharge relationship is based on City of Kitchener topographic mapping and an inlet controlled culvert
  - The attenuated flows are used downstream and immediately upstream of Highway 401 in the hydraulic model in order to determine a rating curve for water levels upstream of Highway 401
  - Flood elevations around Highway 401 are determined by HEC-RAS

- Hydrologic and hydraulic models without Highway 401 and associated upstream storage taken into consideration
  - Flow attenuation (storage) due to Highway 401 is not included in the hydrologic model
  - Uncontrolled flows are used in the hydraulic model downstream of Highway 401
  - Highway 401 is removed from the hydraulic model and water levels upstream of Highway 401 are determined using a rating curve based on the version of the hydraulic model including highway 401.
    - This allows for uncontrolled flows downstream of Highway 401 and backwater effects upstream of Highway 401. Without the rating curve, water levels upstream of highway 401 are artificially increased since a higher water level is required to pass the unregulated flow through the Highway 401 structure

The flood elevations produced by the second model are used for the floodplain mapping.
F.2 Model Results

Flows and flood elevations at significant road crossings are shown in Table 1. A complete listing of flows and flood elevations are shown in Table 2. Floodplain mapping upstream of Highway 401 has been updated using the updated hydraulic modeling and has been appended for reference.

Table 1: Updated Blair Creek Regional Flood Elevations at Road Crossings

<table>
<thead>
<tr>
<th>HEC-RAS Cross Section</th>
<th>Flow Location</th>
<th>Flood Elevations (m)</th>
<th>Flows (m$^3$/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100 year</td>
<td>Regional Storm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>317.95</td>
<td>317.93</td>
</tr>
<tr>
<td>9437</td>
<td>Reidel Drive</td>
<td>307.00</td>
<td>307.00</td>
</tr>
<tr>
<td>7767</td>
<td>Dodge Drive</td>
<td>303.29</td>
<td>303.30</td>
</tr>
<tr>
<td>6897</td>
<td>New Dundee Road</td>
<td>300.46</td>
<td>300.48</td>
</tr>
<tr>
<td>6137</td>
<td>Reichert Drive $^1$</td>
<td>298.99</td>
<td>299.94</td>
</tr>
<tr>
<td>5064</td>
<td>Highway 401</td>
<td>293.62</td>
<td>293.85</td>
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$^1$Flows at Reichert Drive include drainage from Roseville Swamp
## Table 2: Updated Blair Creek Regional Flood Elevations

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APPENDIX G

Photographic Inventory (April 6, 2004)
Photographic Summary of Upper Blair Watershed (April 6, 2004)

Upstream side of New Dundee Rd crossing looking southwest, note GRCA flow gauge

Downstream side of New Dundee Rd crossing looking northeast

Downstream side of New Dundee Rd crossing looking southeast
Downstream side of Dodge Dr crossing looking west

Downstream side of Stauffer Dr crossing (@ Groh Dr) looking south

Upstream side of Dodge Dr crossing looking northwest - Culvert measured as ~1400 x 900 horizontal elliptical

Upstream side of Stauffer Dr crossing (@ Groh Dr) looking north - Culvert measured as ~450 mm diameter
Upstream side of Caryndale Dr crossing north of Stauffer Dr looking west (no evidence of flow)

Downstream side of Caryndale Dr crossing north of Stauffer Dr looking east

Downstream side of Caryndale Dr crossing north of Stauffer Dr looking east at overland flow route - Culvert measured as ~300mm diameter

Upstream side of Stauffer Dr (b/w Reidel and Caryndale) looking northeast to Caryndale

Upstream side of Reidel Dr crossing (just S of Stauffer) looking northwest

Downstream side of Stauffer Dr (b/w Reidel and Caryndale) no culvert observed – possible seepage under road
Downstream side of Reidel Dr crossing (just S of Stauffer) looking east Culvert measured as ~400mm diameter

Downstream side of Reidel Dr main Creek crossing looking northwest - Culvert measured as ~600mm diameter

Upstream side of Reidel Dr facing northeast ~470m north of New Dundee Road (no culvert inlet visible)

Upstream side of Reidel Dr main Creek crossing looking west
Downstream side of Reidel Dr crossing ~380m north of New Dundee Rd facing east (top of culvert (light green) just visible centre of photo, ¼ from bottom)

Downstream side of Reidel Dr crossing ~380m north of New Dundee Rd facing northeast showing overland flow route. Culvert measured as ~375mm diameter

Downstream side of New Dundee Rd crossing facing northeast ~180 m west of Reidel Dr – showing overland flow route

Upstream side of New Dundee Rd crossing facing south ~180 m west of Reidel Dr - Culvert measured as ~500mm diameter

Downstream side of New Dundee Rd crossing facing south ~mid-way b/w Reidel Dr. and Dodge Dr. – showing overland flow route
Upstream side of New Dundee Rd crossing facing north ~ mid-way b/w Reidel Dr and Dodge Dr

Downstream side of New Dundee Rd crossing facing north ~ mid-way b/w Reidel Dr and Dodge Dr

Upstream side of New Dundee Rd crossing facing east ~ mid-way b/w Reidel Dr and Dodge Dr - Culvert measured as ~475mm diameter

Upstream side of New Dundee Rd crossing facing north ~ 300m west of Dodge Drive (culvert id#12009)

Upstream side of New Dundee Rd crossing facing south ~ 300m west of Dodge Drive (culvert id#12009) - Culvert measured as ~875mm diameter
APPENDIX H

Public Open House Information
Notice of Open House
Study Information Handout
Display Boards
Sign-In Sheets
Comment Sheets Received
Notice of Study Initiation and Public Open House

The City of Kitchener has commissioned a Functional Drainage Study for the Upper Blair Creek watershed area within the City of Kitchener, and a Community Plan for the Phase 2 lands identified in the Doon South Community Plan. The purpose of the study is to provide the City of Kitchener, Region of Waterloo and Grand River Conservation Authority with the understanding and technical basis necessary to determine the suitability of the lands to accommodate future urban development in accordance with the objectives of the previous subwatershed study.

The study is proceeding in accordance with the Master Plan requirements of the Municipal Class Environmental Assessment process and therefore, the public is invited to attend the Public Open House to review the work completed to date and provide comments on the study findings.

Date: Tuesday, May 18, 2004
Time: 6:00 PM to 8:00 PM
Location: Doon Pioneer Community Centre

Following this meeting, the study report will be completed and presented to the Development and Technical Services Committee before consideration by Council. Once approved, the study will be placed on public review for a period of 30 days. Interested parties will then have the opportunity to comment on the recommendations. If no comments are received by the end of the review period, the project may proceed as presented.

Please address your comments or inquiries for further information to:

Mr. Larry Masseo                  Mr. Steve Brown, MBA, P.Eng.
City of Kitchener                  Stantec Consulting Ltd.
Manager of Design and Development  49 Frederick Street
Planning Division, 6th Floor       Kitchener, ON N2H 6M7
200 King Street West              Phone: (519) 585-7446
P.O. Box 1118                     Fax: (519) 579-8664
Kitchener, ON N2G 4G7             
Phone: (519) 741-2305
Fax: (519) 741-2624
INTRODUCTION

The Upper Blair Creek subwatershed and Doon South (Phase 2) Community Plan areas are located at the southwest limits of the City of Kitchener, and represent the headwaters of the Blair Creek system that outlets to the Grand River approximately 9 km downstream at the Village of Blair.

While extensive background work has been completed to date, an Implementation Plan for the Blair Bechtel and Bauman (BBB) Subwatershed Plan (1997) has yet to be developed. In order to guide future planning decisions within the area of the subwatershed currently under investigation, it is considered timely to prepare a functional drainage plan for the Upper Blair Creek and Doon South (Phase 2) Community Plan Areas that provides an optimal balance of all relevant natural, social, and economic criteria. The preferred alternative must establish an appropriate development strategy and associated mitigation plan (stormwater management), on a subwatershed level, to most effectively meet the needs of all stakeholders and achieve the objectives of the BBB Subwatershed Plan.

The Implementation Plan component of the Study will consist of the development of a draft Community Plan for the Doon South (Phase 2) Area and a Functional Drainage Study, which will provide an explicit set of design criteria that must be achieved within given development areas. The technical analysis that will be documented to validate the Preferred Alternative will provide the City of Kitchener, the RMOW, and the GRCA with the understanding and technical basis necessary to consider future applications.
Alternate Design Concepts

As part of the Class Environmental Assessment Process, it is important in the environmental review that all reasonable design alternatives be adequately considered. The following alternatives, and preliminary assessments, have been identified:

1. Do nothing – i.e. maintain Study Area in existing conditions
   - Not in conformance with the current Municipal Land Use Plan
   - Recommended greenspace areas remain unprotected

2. Develop the Study Area using “Standard” Approach
   - Significant negative environmental impact associated with this approach, including
     o Increased flooding and erosion in the Blair Creek system
     o Reduced infiltration and associated base flows
     o Degraded water quality (increased temperature)
   - Unacceptable environmental impact

3. Develop the Study Area using “Approved” Approach
   - Maximum impervious cover restrictions limit development options to estate residential use
   - Limited service residential requires individual septic systems which do not meet Regions servicing policies (centralized sanitary servicing)

4. Develop the Study Area using “Innovative” Approach
   - More dense development permitted with more comprehensive mitigation measures required
   - Significant infiltration required, particularly in the upper reaches of the watershed

An evaluation of these options with respect to impacts on the natural environment, the social environment and technical considerations is ongoing and findings to date are displayed with the information material.

♦♦♦♦♦

Next Steps

Following this meeting, the study report will be completed and presented to the City’s Development and Technical Services Committee prior to consideration by Council. Once approved, the study will be placed on public review for a period of 30 days, during which time interested parties will have the opportunity to comment on the recommendations. If no comments are received by the end of the review period, the project may proceed as presented.

♦♦♦♦♦
MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT PLANNING & DESIGN PROCESS

NOTE: This flow chart is to be read in conjunction with Part A of the Municipal Class EA

1. IDENTIFY PROBLEM OR OPPORTUNITY
   - Examine current conditions and determine if a problem or opportunity exists.

2. IDENTIFY ALTERNATIVE SOLUTIONS TO PROBLEM OR OPPORTUNITY
   - Identify potential solutions that could address the problem or capitalize on the opportunity.

3. SELECT SCHEDULE (APPENDIX)
   - Prioritize the solutions based on specific criteria.

4. INVENTORY NATURAL, SOCIAL, ECONOMIC ENVIRONMENT
   - Examine the environmental, social, and economic factors that could impact the project.

5. IDENTIFY IMPACT OF ALTERNATIVE SOLUTIONS ON ENVIRONMENT
   - Evaluate the potential environmental impacts of each alternative solution.

6. EVALUATE ALTERNATIVE SOLUTIONS, IDENTIFY RECOMMENDED SOLUTION (APPENDIX)
   - Select the most appropriate solution based on a comprehensive evaluation.

7. CONSULT PUBLIC & INDIVIDUALS
   - Engage with the public and all stakeholders to gather their input and concerns.

8. SELECT PREFERRED SOLUTION
   - Confirm the chosen solution with the stakeholders.

9. DEVELOP PROPOSED DESIGN CONCEPTS FOR PREFERRED SOLUTION
   - Create designs that align with the selected solution.

10. ENVIRONMENTAL STUDY REPORT: DRAFT
    - Prepare a detailed report outlining the environmental impacts and mitigation measures.

11. ENVIRONMENTAL STUDY REPORT: FINALIZED
    - Finalize the report based on public feedback and any required revisions.

12. NOTICE OF COMPLETION TO PUBLICATION (PUBLIC POSTING)
    - Officially announce the completion of the environmental assessment.

13. CORRECTIVE MEASURES ONE & TWO (APPENDIX)
    - Implement any necessary corrective actions to mitigate environmental impacts.

14. MATTER IN COURT
    - Address any legal issues or concerns that arise during the process.

15. ORDER ISSUED (APPENDIX)
    - Finalize the order of construction and operation.

16. IMPLEMENTATION
    - Execute the plan according to the approved schedule and design.

17. COMPLETE CONTRACT DRAWINGS AND TENDER DOCUMENTS
    - Prepare all necessary documents for the implementation phase.

18. PROCEED TO CONSTRUCTION AND OPERATE
    - Begin the construction phase and prepare for operation.

19. MONITOR FOR ENVIRONMENTAL PROVISIONS AND COMPLIANCE
    - Continuously monitor the project to ensure compliance with environmental regulations.

20. REPORTS FOR ENVIRONMENTAL PROVISIONS AND COMPLIANCE
    - Provide regular reports on environmental performance and compliance.

21. ENVIRONMENTAL ASSESSMENT
    - Conduct a thorough assessment of the project's environmental impacts.

22. UPPER BLAIR CREEK FUNCTIONAL DRAINAGE STUDY & DOON SOUTH (PHASE 2) COMMUNITY PLAN
    - Conduct a detailed study of the drainage system and prepare a plan for the community.

MAY 18, 2004
610310687 EA CHART.dwg

ENVIRONMENTAL ASSESSMENT
Kitchener, Region of Waterloo, and Stantec Consulting Engineers
MacKinnon & Associates

McWhinney Strategic Plan, 2002-2007
**Study Objective**

A functional drainage plan is required for the Upper Blair Creek and Doon South (Phase 2) Community Plan Areas that provides an optimal balance of all relevant natural, social, and economic criteria. The preferred alternative must establish an appropriate development strategy and associated mitigative plan (stormwater management), on a subwatershed level, to most effectively meet the needs of all stakeholders and achieve the objectives of the BBB Subwatershed Plan.

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<th>Alternative 3</th>
<th>Alternative 4</th>
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<td>Preliminary Assessments</td>
<td>• Not in conformance with the current Municipal Land Use Plan. • Recommended greenspace areas remain unprotected.</td>
<td>• Analysis completed previously as part of the Blair, Breslau, and Bauman (BBB) Creeks Subwatershed Plan (1997) and the Blair Creek Watershed Hydrology Model: Revisions Draft Summary Report (2001) conclude an unacceptable environmental impact is associated with this approach, primarily including: o Increased flooding and erosion in the Blair Creek system, o Reduced infiltration and therefore base flows, o Degraded water quality (increased temperature).</td>
<td>• Limited service residential requires individual septic systems which do not meet Region’s servicing policies (centralized sanitary servicing). • Provision of centralized municipal services not economically viable with estate lot size development.</td>
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### Summary of Stormwater Management Best Management Practices (SWM BMP's)
(BMP's in blue are those that show promise from a technological feasibility and acceptability perspective)

**Prevention**
- Promotion of High Density Development Clusters
- Alternative Development Standards
- Reduced Access Widening
- Reduced House Setbacks
- Alternative Turn-Around Standards for Dead-Ends

**Lot Level / All-Source Controls**

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**Conveyance Controls**
- Gravel Swales
- Permeable Pipes
- Permeable Catch Basins
- Swale and Permeable Pipe Infiltration System
- Filters / Silt Blocks
- Off-Line Infiltration galleries within parks or "Toi Law"
CITY OF KITCHENER
Upper Blair Creek (Kitchener) Functional Drainage Study and
Doon South (Phase 2) Community Plan

Public Open House
May 18, 2004

ATTENDANCE REGISTRATION

Thank you for attending the Public Open House, we would appreciate a record of those attending. Please print legibly:

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<tr>
<th>Name</th>
<th>Address</th>
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<tr>
<td>Rick Hardi</td>
<td>260 Huron Rd</td>
<td>748-9049</td>
</tr>
<tr>
<td>Bradley Marin</td>
<td>31 Hearthwood Cres</td>
<td>896-9250</td>
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<tr>
<td>Anne Lee Moore</td>
<td>320 Dodger Dr</td>
<td>748-9475</td>
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<tr>
<td>Bill Elliott</td>
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<td>744-5728</td>
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<tr>
<td>Terry Pickert</td>
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<tr>
<td>Carol Johnston</td>
<td>121 Dodge Dr.</td>
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<tr>
<td>Tim &amp; Marc Hasler</td>
<td>230 Dodge Dr.</td>
<td>893-9488</td>
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<tr>
<td>Wendy John Thayer</td>
<td>730 New Avenue Rd</td>
<td>693-9616</td>
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<tr>
<td>Paul &amp; Alain Legum</td>
<td>258 Dodge Dr.</td>
<td>894-9479</td>
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<tr>
<td>Ruth Kosinski</td>
<td>500 Stacullen Dr</td>
<td>748-2132</td>
</tr>
<tr>
<td>Bob &amp; Brenda Becker</td>
<td>1122 Bethel Rd, RRI 1</td>
<td>696-3194</td>
</tr>
</tbody>
</table>

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# CITY OF KITCHENER
Upper Blair Creek (Kitchener) Functional Drainage Study and
Doon South (Phase 2) Community Plan

Public Open House
May 18, 2004

## ATTENDANCE REGISTRATION

Thank you for attending the Public Open House, we would appreciate a record of those attending.
Please print legibly:

<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pieter Katherlik</td>
<td>628 New Lange Road</td>
<td>884-2815</td>
</tr>
<tr>
<td>Steve Rooke</td>
<td>MTN Consultants 650 Waterloo Kitchener</td>
<td>743-6500</td>
</tr>
<tr>
<td>Frank Paul</td>
<td>372 Biemel Dr Kitchener NZR1C4</td>
<td>748-1763</td>
</tr>
<tr>
<td>Odette Caron</td>
<td>516 Caryndale Dr</td>
<td>896-9275</td>
</tr>
<tr>
<td>Zyga Jansev</td>
<td>PE 379 Queen St S N2G 1W6</td>
<td>745-9455</td>
</tr>
<tr>
<td>Brian Urengren</td>
<td>653 Willerworth Dr Waterloo N2T 2T7</td>
<td>885-7914</td>
</tr>
<tr>
<td>Erwin Buehnke</td>
<td>80 Chippewa Rd McKeen</td>
<td>748-5189</td>
</tr>
<tr>
<td>Nikolai &amp; Hash Saard</td>
<td>424, New Duidee Rd Kitchener N2B 2N7</td>
<td>895-0119</td>
</tr>
<tr>
<td>Sue Sam Jantzen</td>
<td></td>
<td>744-1848</td>
</tr>
<tr>
<td>Della Goetz</td>
<td>76 Kilkerran Cr Kitchener NZR1B9</td>
<td>748-9782</td>
</tr>
<tr>
<td>Tony Christke</td>
<td>321 Dodge Dr N2B 2N2</td>
<td>895-1288</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>Telephone</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALEX SERWATZEK</td>
<td>176 Green Vista Dr.</td>
<td>623-7774</td>
</tr>
<tr>
<td>SCHERL, Anne</td>
<td>1198 Fischer Hallman Rd.</td>
<td>576-7634</td>
</tr>
<tr>
<td>Stephen Braun</td>
<td>590 Willow Rd., Guelph ON N1H 7G4</td>
<td>836-9892</td>
</tr>
<tr>
<td>JACQUES MORDON</td>
<td>98-270 Morrison Rd, NZA 3Y1</td>
<td>894-5807</td>
</tr>
<tr>
<td>MIKAEL DE JABOM</td>
<td>30 Woodview Crt F14</td>
<td>569-7387</td>
</tr>
<tr>
<td>WERNER &amp; ALICE BROMBERG</td>
<td>RR4 BRIGHT, ON NOT 180</td>
<td>632-5013</td>
</tr>
<tr>
<td>ROB SCHLEGEL</td>
<td>40 Frederick St</td>
<td>571-1873</td>
</tr>
<tr>
<td>YVONNE FERNANDES</td>
<td>52 Kilbrinie CRT Kit, NZR 1J5</td>
<td>748-1659</td>
</tr>
<tr>
<td>B. MILLER</td>
<td>Cambridge</td>
<td></td>
</tr>
<tr>
<td>JERRY WORTHINGTON</td>
<td>19 Huntwood Kit</td>
<td>572-5272</td>
</tr>
<tr>
<td>JIM &amp; EVELYN GOWMAN</td>
<td>418 New Dundie Rd</td>
<td>898-0595</td>
</tr>
</tbody>
</table>

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CITY OF KITCHENER
Upper Blair Creek (Kitchener) Functional Drainage Study and
Doon South (Phase 2) Community Plan

Public Open House
May 18, 2004

COMMENT SHEET

Thank you for your interest in this project. You are encouraged to provide your comments by leaving them in the box provided at the Public Open House or forwarding them to:

Mr. Larry Masseo
City of Kitchener
City Hall Complex, 6th Floor
P.O. Box 1118
Kitchener, ON N2G 4G7
fax: 741-2624

Please print legibly. Comments may be published.

| NAME:   | TIM HASENPFLUG |
| ADDRESS: | 230 DODGE DR. |
| TELEPHONE: | 893-9488 |

<table>
<thead>
<tr>
<th>COMMENTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>○ Please lower the environmental impact as designed. Let's preserve some wild life areas.</td>
</tr>
<tr>
<td>○ Town should not be a through street as outlined. Originally it was to be closed.</td>
</tr>
<tr>
<td>○ Keep the area as estate residential area,</td>
</tr>
</tbody>
</table>

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fax: 741-2624

Please print legibly. Comments may be published.

NAME: Bradley Marin
ADDRESS: 81 Hearthwood Crescent Kitchener, ON N2B 1K7
TELEPHONE: 519 896 9250
COMMENTS: I would like to be informed with
respect to future development on this property
specifically with respect to the follow:

- zone changes, traffic patterns,
  green space, surface water treatment,
  protection of flora & fauna.

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P.O. Box 1118  
Kitchener, ON N2G 4G7  
fax: 741-2624

Please print legibly. Comments may be published.

NAME: Alain Lajeunesse & Paula Rogers  
ADDRESS: 258 Dodge Drive  
TELEPHONE: 894-9479

COMMENTS: We have some concerns with the study:  
a) Impact on our current well water. Today we have excellent quality & don't want to change supply  
b) Road traffic considerations - the proposed changes will significantly alter the neighborhood dynamics  
c) Environmental implications - on local wildlife such as birds & deer.  
Based on the design options provided we would support alternative 3 - Approved. This is what we wanted & purchased when we came to this region.
CITY OF KITCHENER
Upper Blair Creek (Kitchener) Functional Drainage Study and
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Kitchener, ON N2G 4G7
fax: 741-2624

Please print legibly. Comments may be published.

NAME: KAREN A. SCHERL
ADDRESS: 832 STIRLING AVE S, KITCHENER ON N2S 3K3
TELEPHONE: 576-7634

COMMENTS: Thank you very much for the opportunity to learn more about the above. I learned that the most recent watershed study being used as the basis for the abovementioned Community Plan is 10 years old (Blair Bechtel Bauman Study). Therefore, I seriously wonder whether the abovementioned Study & Plan are being based on up-to-date information which reflects reality. If not, they are a big waste of money. I highly recommend that the City, Region & RGA utilize the expertise of its personnel to conduct a new watershed study for the whole area first and then proceed with the abovementioned Study & Plan.
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Kitchener, ON N2G 4G7
fax: 741-2624

Please print legibly. Comments may be published.

| NAME:     | ANNE SCHELU |
| ADDRESS:  | 1198 FISCHER-HALLMAN RD. KITCHENER ON. N2R 1P5 |
| TELEPHONE:| 745-1539 |

COMMENTS: Please mail me all further notices of all future meetings,
information sessions, a copies of studies relating to the above mentioned
Please also notify me when the study report referred to in your
Information Brief is placed on public review so that I have an
opportunity to comment on the recommendations.

Thank you.

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Kitchener, ON N2G 4G7
fax: 741-2624

Please print legibly. Comments may be published.

NAME: Della Goetz
ADDRESS: 76 Kilkerran Cr
TELEPHONE: 748-9782

COMMENTS: A great deal of consideration must be made to ensuring that building structures, residential or commercial are not constructed too close to spring fed water ways and wetlands. A good example is Kilkerran Cresc., K26 well & Greater land + the tributary that feeds into Strasburg Creek.

If you wish to consult Hennie Fourné, engineer for the Region, you will understand the issues that still remain unresolved since the homes were built @ 1988. Feel free to contact me if you wish.

Della

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City of Kitchener  
City Hall Complex, 6th Floor  
P.O. Box 1118  
Kitchener, ON N2G 4G7  
Fax: 741-2624

Please print legibly. Comments may be published.

<table>
<thead>
<tr>
<th>NAME</th>
<th>ANNALEE MOORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDRESS</td>
<td>380 DODGE DR KITCHENER</td>
</tr>
<tr>
<td>TELEPHONE</td>
<td>748-9475</td>
</tr>
</tbody>
</table>

**COMMENTS:**  

I am opposed to the extension of Dodge Drive & the change to the approved Community Plan that would see the portion of Road from Dodge to McTavish kept open rather than joining part of the Community Trail. The additional traffic on Dodge will affect the homeowners, the environment & the heritage aspects of Dodge Drive. Please keep me informed. I would like to address Council on this matter.
CITY OF KITCHENER
Upper Blair Creek (Kitchener) Functional Drainage Study and
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City Hall Complex, 6th Floor
P.O. Box 1118
Kitchener, ON N2G 4G7
fax: 741-2624

Please print legibly. Comments may be published.

<table>
<thead>
<tr>
<th>NAME:</th>
<th>Yvonne Fernandes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADDRESS:</td>
<td>52 Kubieniec CRT</td>
</tr>
<tr>
<td>TELEPHONE:</td>
<td>748-1659</td>
</tr>
<tr>
<td>COMMENTS:</td>
<td>I am extremely interested in being kept abreast of this issue</td>
</tr>
</tbody>
</table>

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City of Kitchener  
City Hall Complex, 6th Floor  
P.O. Box 1118  
Kitchener, ON N2G 4G7  
fax: 741-2624

Please print legibly. Comments may be published.

**NAME:** Anthony Christie  
**ADDRESS:** 321 Dodge Dr  
**TELEPHONE:** 595-1284  
**COMMENTS:** See Attached.
Attn: Mr. Larry Masseo  
City of Kitchener  
City Hall Complex, 6th Floor,  
P.O. Box 1118  
Kitchener, ON  
N2G 4G7

The first part of this letter contains my impressions after reading the Doon South Community plan, dated May 1997. The second part adds some comments I would like to make in response to tonight’s Public Open House (May 18, 2004).

First Part

Several things come to mind upon a cursory first glance at this very interesting document.

While impressed with the near-comprehensiveness of the issues examined, I find that I am disappointed in several aspects of the plan e.g.

a) ...it envisions development along the lines of fairly typical i.e. super-automobile-dependent subdivisions with a very few isolated service locations not within convenient walking distance of most residents. The result will be the usual sterile and anonymous suburban meandering road network faced on either side by endless vistas of garage doors, the dominant architectural feature of our time.

b.) Most of the too-small amount of designated "Active Park"-land is located in the Hydro Corridor, i.e. the leftover land that the developers couldn’t build upon and sell anyway. I wonder if City Planners ever visited parks such as these? I personally find them scary and spooky places, dominated as they are by the giant hydro towers. They are usually deserted. Contrast this with the vibrant busy places that we traditionally designated for this use, e.g. Victoria Park, Waterloo Park, Central Park (N.Y.N.Y.), High Park (Toronto), etc. The difference is, that we once-upon-a-time recognized the true value of urban parks and gave them prime real estate, not the dregs as now. Also there’s lots of controversy surrounding theories that the powerful e.m. fields associated with the high-voltage high-tension lines are health-hazardous, particularly to children who would comprise an important cohort of parks' clientele, presumably. Whether these hazards are real or not is only half of the point. People believe they are and avoid such places. Hardly the welcoming face one would hope for a park to show the public.

c.) While the network of scenic roads becoming community trails is an excellent idea it is disingenuous in the extreme to designate the 5 meter-each side as equivalent to parkland. These corridors, while very nice, are properly recognized as ditches and roadside scrub. Not the same thing as a park, and no substitute.

d.) Spillover traffic from Street H and the subdivisions is going to negatively impact Dodge Drive; indeed already is. Groh and Dodge provide an unpatrolled and attractive to some “short-cut" to Regional Rd. 12 (New Dundee Rd.). This scenic route should not be an access route to the newly developed areas, nor from then to the arterial road system.
Groh should be closed south of Street H as well as north as is currently envisioned in the plan. I can think of no one who would be negatively affected by this (other than the "short-cutters" who were never intended, according to the Plan to benefit from this alternative access route anyhow), and the scenic, recreational, peaceful, traditional character of the Dodge Drive neighbourhood would be much better preserved. Already in the brief 17 months I have been resident, there has been a tremendous increase in the volume of commuter traffic on Dodge, and don't get me started about the construction traffic including huge fully loaded dumptrucks, etc. which are prohibited but ignore the unenforced prohibition.

Furthermore, the corner of Dodge and Groh is quite dangerous especially in winter, and has already been the site of several very serious accidents (southbound traffic on Groh too frequently slides through the intersection and down the embankment into my side yard). One victim lost his spleen, I am told. It is not inconceivable that one day someone will partially make the turn and drive into my living room, which is very close to the road.

Dodge Drive, according to a maps at the Doon Heritage Crossroads Museum, was once the main thoroughfare west to New Dundee, and as such is an extremely important heritage asset in relatively pristine condition, especially that portion west of Groh Drive. One can stand at the corner of Groh and Dodge, looking west, and very easily imagine that it is actually 1850 and that you have been time-transported; that’s how pristine and unchanged the street-scape has remained. We would be foolish indeed to trade this for an on/off-ramp/collector/sub-arterial/connector/ or whatever is contemplated.

Second Part
After seeing the initial proposal for phase two I confess to being quite horrified by the idea to use the south portion of Groh Dr. and the western portion of Dodge Drive as a connector route (Proposed Road "A") between the Phase One development area and the Phase Two western bits. This would hugely increase traffic in front of my family’s home, a home we purchased only a year ago, ironically, in order to enjoy it’s bucolic setting.

Actually, it is difficult to see how this route for Road "A" would even be possible given the siting of our home and that of the converted schoolhouse at 320 Dodge. Something would have to give, merely to provide a sufficiently wide road right-of-way.

It appears from maps at the Doon Heritage Crossroads Museum that our 1940’s house is sitting upon an 1850’s foundation. The barn may date to this period as well. It would be interesting to know who originally settled this property. That they must have been one of the first European settlers in the area cannot be doubted, as the land was part of a huge grant of property made by the Crown to a fellow named Beasley only 70 years or so prior to the date referred to above, as is indicated in the Land Registry offices on Frederick St. I will attempt to undertake more research in this area. It is likely that any other information discovered will enhance the area’s already important heritage value, rather than detract from it.

One of the reasons given for this use of the Dodge Drive Route is that no other crossing of the Blair Creek would need to be constructed, as
the existing one, i.e. the tiny Dodge Drive culvert would serve, which is obviously, even to a neophyte in the matters, not the case. The existing crossing would in no way serve as the planners well know, and the improvement of it to the standard required by the proposal would be tantamount in every respect to the construction of a new crossing. Only the "map-site" would be the same. The real "on-the-ground" site, of course, would be unrecognizable.

The Dodge Drive culvert has existed for a very long time (indeed the culvert might itself be considered an heritage asset!), it is so old and the creek and the ecosystem have long ago accustomed themselves to it and accommodated it. The new crossing, no matter where it is sited, will be far, far more disruptive.

Thanks Very Much,
Sincerely,
Tony Christie
APPENDIX I

References / Reading List
References / Reading List

General

Analysis of Groundwater Conditions in the Cedar Creek Subwatershed

CH2M Gore & Storrie, Gartner Lee Ltd., Mark L. Dorfman, Planner Inc., Schroeter and
Associates, Blair, Bechtel, and Bauman Creeks Subwatershed Plan, for the
Grand River Conservation Authority, January 1997

CH2M Gore & Storrie, Gartner Lee Ltd., Mark L. Dorfman, Planner Inc., Schroeter and
Associates, Blair, Bechtel, and Bauman Creeks Subwatershed Plan – Appendix
B: Hydrology/Hydraulics/Temperature Modelling, for the Grand River
Conservation Authority, January 1997

GRCA (Jeff Marshall / Leslie Cope, Environmental Services Group), Blair Creek Habitat
Assessment and Fishery Inventory, November 1991

KMK Consultants Ltd., Upper Doon Sewage Pumping Station – Doon South Community,
Phase 2 Service Area Expansion Study, for the City of Kitchener, Revised
March 1998


Parish Geomorphic, Geomorphological Thresholds for Instream Flow Requirements
(Final Draft), for the Grand River Conservation Authority as part of the Grand
River Instream Flow Study Pilot Project, July 2004


Schroeter and Associates, Blair Creek Watershed Hydrology Model: Revisions (Draft
Summary Report), for the Grand River Conservation Authority, March 26, 2001

SWM Technology Review

Caraco and Claytor, Stormwater BMP Design Supplement for Cold Climates, for the
USEPA Office of Wetlands, Oceans, and Watersheds, December 1997

Elfering, Jody Mary, Improving the Design of Roadside Ditches to Decrease Transportation
Related Surface Water Pollution, University of Minnesota – Dept. of Water Resource
Sciences, November 2002 (document available for download at
http://www.mrr.dot.state.mn.us/research/MnROAD_Project/MnRoadOnlineReports.asp


Scholz-Barth, Katrin, *Green Roofs: Stormwater Management From the Top Down*, Environmental Design + Construction, article posted 01/15/2001 (document available at [http://www.edcmag.com](http://www.edcmag.com))


**Road Salt Management and Associated Groundwater Impacts**


APPENDIX J

Study Terms of Reference
April 28th, 2003

E03-030

EXPRESSION OF INTEREST FOR CONSULTANT SERVICES
UPPER BLAIR CREEK (KITCHEENER) FUNCTIONAL DRAINAGE STUDY
AND DOON SOUTH (PHASE 2) COMMUNITY PLAN

The City of Kitchener requires a qualified Consultant to complete the following: Upper Blair Creek (Kitchener) Functional Drainage Study and Doon South (Phase 2) Community Plan as per the attached Terms of Reference.

A Consultant’s Review Committee will review the Expressions of Interest received and proceed with the selection process.

Your Expression of Interest should address the items noted in the Terms of Reference and be no longer than TEN pages.

Your response MUST include the following:

- A list of all personnel to be assigned to the project team together with a personal resume for each individual to be associated with the project.

- A description of previous projects of a similar nature performed by your firm, including a complete description of the work completed by your firm, the names of your staff and their assignments in the project, the names of your clients and the name and phone number of an individual that may be contacted for reference purposes.
Full costing information **will not** be necessary at the time of submission of your Expression of Interest, but will be required at the interview stage.

Responses that do not include all requested information will **NOT** be considered.

Please submit **ten (10)** copies of your Expression of Interest to:

The Corporation of the City of Kitchener  
Mr. Larry Gordon  
Director of Purchasing  
4th Floor, City Hall  
200 King Street West  
Kitchener, Ontario  
N2G 4G7

**NO LATER THAN 12:00 NOON, LOCAL TIME, TUESDAY MAY 13TH, 2003.**

Responses received after that time **will not be accepted** under any circumstances.

Yours truly

[Signature]

Larry Gordon  
Director of Purchasing  
LG/ab  
Attach.
Upper Blair Creek (Kitchener) Functional Drainage Study and Doon South (Phase 2) Community Plan

Terms of Reference

Background

In 1997, a partnership consisting of the Ministry of Natural Resources, Grand River Conservation Authority, Regional Municipality of Waterloo, City of Kitchener and City of Cambridge completed the Blair, Bechtel and Baumen Creeks Subwatershed Study (BBB Study). This study was undertaken in order to address the management and enhancement of surface and ground water, the maintenance of stream and aquatic systems, and the conservation of natural heritage features. The BBB Subwatershed Study recommended that the following measures be taken to protect the stream ecosystem from the impacts of future development:

- Impervious Cover Limits (ICL’s) to limit the paved areas and other hard surfaces within the watershed and maximize opportunities for ‘at-source’ infiltration of precipitation;
- “Best Management Practices” to control the quality and the quantity of storm water discharging to the Blair Creek system; and
- Protection and conservation of natural heritage features and functions within a comprehensive, connected greenspace system.

These stream systems are characterized as sensitive cold water fisheries which are highly dependant upon the groundwater discharge and sensitive to changes in flow and thermal regime.

The BBB Study identified the following primary issues relating to storm water management (SWM) associated with potential urban development of the upper Blair Creek watershed:

- Change in water balance within the system (reduction in infiltration and in evapotranspiration, leading to greatly increased surface runoff)
- Increase in flood flows from the developing areas especially relating to loss of major natural depression storage areas and land use change,
- Increased stream erosion potential based on increased flow volumes and durations above stream erosion thresholds from extended detention facilities,
- Increased durations of elevated stream temperatures from SWM facility discharges to the stream.

The BBB Study recommended the use of ICL’s in order to maximize opportunities of ‘at-source’ infiltration of precipitation. The supporting references for use of ICL’s has come from various macro scale studies which demonstrate a correlation between watershed imperviousness and degradation of watercourses and aquatic habitat especially in cold-water fisheries. This approach has also recently been adopted in the Oak Ridges Moraine legislation and Conservation Plan.

The ICL approach was recommended to reduce the following risks that can be associated with land use change and development:

FINAL – March 31, 2003
• Designation for higher density development in the absence of sufficiently detailed soils and groundwater information that properly evaluates the feasibility of implementing necessary infiltration measures (e.g. under current planning approval practices, development projects often reach final design level before determination of the suitability of soils to achieve infiltration targets);
• Implementation, operation and maintenance of certain infiltration measures can be cost prohibitive and are often not financially sustainable for the municipality;
• Reliance on engineered SWM systems and facilities to achieve infiltration of precipitation; is a relatively recent approach to SWM;
• Infiltration measures currently demonstrate high failure rate; and
• Infiltration of runoff from road surfaces can increase the potential for contamination of the groundwater system.

Subsequent to the completion of the BBB Study, the Grand River Conservation Authority has carried out the following specific activities relating to the stream hydrology and SWM implementation:
• Installation of longer term continuous flow gauges on Blair Creek;
• Additional temperature monitoring;
• Update of BBB GAWSER hydrologic modelling reflecting revised calibration based on additional flow record and incorporating infiltration measures in SWM scenarios;
• Review of recent infiltration based SWM approaches applied in other areas of GRCA watershed, and;
• Review of pollution prevention measures.

The update of the hydrologic modelling indicated that stream targets could be met provided sufficient precipitation could be infiltrated at source. The GAWSER modelling could be used as the basis for hydrologic targets in subcatchment areas (water balance, infiltration, stream erosion, flood flows).

As a result of the above noted review of SWM approaches and pollution prevention measures, the following strategies show promise:
• Maximizing at-source infiltration of precipitation;
• Disconnection of all impervious surfaces from direct contribution to end of pipe SWM basins and discharge to the stream system;
• Areal distribution and redundancy of infiltration facilities including the location of facilities high in the landscape rather than at the lowest point (where SWM ponds are typically sited);
• Infiltration facilities in municipal ownership to ensure long-term maintenance and operation;
• Seasonal disconnection of infiltration facilities conveying road runoff to reduce chlorides entering the groundwater system; and
• Management of road de-icing operations.

Other work, involving the collection of detailed soil and groundwater information and determination of infiltration feasibility, has also been carried out by MTE Consultants Inc. and Naylor Engineering Associates Limited. While data collection was limited to specific land

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parcels, the work indicates a spatial variability in soil and groundwater conditions throughout subject area, which would limit the generic application of infiltration measures.

Next Steps

The BBB Study recommended a maximum ICL of 25% for the Upper Blair Creek watershed in Kitchener. However, an implementation plan for the BBB Study has yet to be completed. In order to guide future planning decisions within various portions of the watershed, it is timely to prepare a functional drainage plan, which will assess whether alternative storm water management techniques can achieve the same objectives as ICL’s within an urban context. A functional drainage study will establish an appropriate strategy, to be developed and implemented on a subwatershed level, to achieve the objectives of the BBB Study.

The East Study Area, being the lands located to the east of Reidel Drive, generally reflects the extent of the Doon South Community Plan – Phase 2 area. These lands are currently designated “Limited Service Residential” in the City’s Municipal Plan, which provides for large lot residential development on individual wastewater treatment systems subject to review through the servicing hierarchy. However, in keeping with the established servicing policies in the Region of Waterloo, the City has determined that the lands can be serviced to a centralized municipal wastewater system by way of a sanitary pumping station and forcemain.

If the East Study Area lands are to be economically provided with centralized municipal sanitary services, higher overall densities must be achieved than those which are currently permitted by the City’s Municipal Plan. A functional drainage study, together with a community plan component, will provide the City of Kitchener, the Regional Municipality of Waterloo and the Grand River Conservation Authority with the understanding and technical basis necessary to consider fully serviced residential development in accordance with the objectives of the BBB Study. The functional drainage study will identify the preferred specific engineering, SWM and land use planning methods necessary to allow fully serviced urban development in a manner that is consistent with the objectives of the BBB Study.

The West Study Area, being the lands located to the west of Reidel Drive, are primarily agricultural and are currently located outside the urban development boundary as defined in the Regional Official Policies Plan and the City of Kitchener Municipal Plan.

A portion of the West Study Area is being considered for a possible future extension to the urban development boundary. A scoped functional drainage study will provide the City of Kitchener, the Regional Municipality of Waterloo and the Grand River Conservation Authority with the understanding and technical basis necessary to determine the suitability of the lands to accommodate future urban development in accordance with the objectives of the BBB Study. This information will then be pertinent to any future planning decisions that may extend the urban development boundary into this area. The scoped functional drainage study will not address specific methods or locations of future SWM facilities in the West Study Area.

The full study area is shown generally on the map below.
Major Study Tasks and Deliverables

For the East Study Area:

1. Conduct an environmental scan of the technology and effectiveness of applicable storm water “best management practices” which have been implemented on lands with similar constraints in other jurisdictions. This to include:
   - a review and investigation of potential SWM techniques implemented in other moraine areas and jurisdictions, including evaluation of risks, long term effectiveness, and maintenance costs and requirements; and
   - a review of recent road salt application and chloride contamination studies and policy direction regarding chloride effects in evaluation of risks on receiving systems.

2. Complete a detailed hydrogeologic investigation of the soils in the study area. The groundwater investigation is to identify the potential to implement infiltration practices within the study area and will make use of both existing and new information as necessary. This component is to include an analysis of topographical mapping, the completion of boreholes and/or test pits, determination and mapping of infiltration rates, and groundwater monitoring including seasonal variation in depth to water table.

3. Identify preferred methods and locations of storm water management facilities, including infiltration targets, effective lot level and communal source-controls, and municipal infrastructure that
   - minimizes the amount of additional storm water that must be conveyed to and accommodated in streams, and
   - maximizes the amount of precipitation infiltrated at source.

Identify and evaluate infiltration within depression storage areas.

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4. Perform hydrologic modelling using GRCA BBB continuous and event based GAWSER model. Make model refinements and validation to reflect subcatchment delineation, recharge depression reservoirs, and drainage paths based on detailed topographic mapping, and site investigations (including wet weather and melt period). Modelling approach should be made in consultation with GRCA technical staff. Make necessary model revisions to reflect drainage modifications and additional subcatchment breakdown as required to reflect potential development patterns within Upper Blair watershed and with existing or committed development in adjacent Doon Watershed.

Use GAWSER model to confirm SWM approach meets existing conditions in subcatchment and stream areas for water balance, flow duration (especially relating to stream erosion thresholds), return period and regional flows and stream temperatures.

Predict loading and impacts of potential contaminants (including chlorides) on receiving system.

5. Pose alternative scenarios for the distribution, form and density of urban development within the study area.

6. Undertake and document a landowner and public consultation process as part of the Community Plan preparation.

7. Complete a Community Plan for Doon South Phase 2 (East Study Area) that:
   - identifies a greenspace system, and recommends measures to protect the features and functions of its major elements;
   - identifies an appropriate distribution of density and development forms that will complement the preferred methods for storm water management;
   - identifies the future residential land use pattern together with the collector road system, park locations, open space features, and school sites necessary to support this pattern; and
   - establishes appropriate policies, practices and standards to ensure that the future development form is consistent with the objectives of the BBB Study.

8. Classify and document all of the above in accordance with the Master Plan requirements of the Municipal Class Environmental Assessment process.

For the West Study Area:

Complete items 1, 2 and 4 as described above.
Cost Estimate

The cost estimate is between $80,000 to $100,000 for the completion of the functional drainage study and community plan for the East Study Area; to be cost shared as follows:

- 50% attributable to the City of Kitchener, Regional Municipality of Waterloo and Grand River Conservation Authority; and

- 50% attributable to the affected landowners within the study area.

All costs related to the completion of the scoped functional drainage study for the West Study Area are to be separately documented and shall be borne entirely by the affected landowners.

Project Administration and Steering Committee

The project will be administered by Larry Masseo, Manager of Design and Development and Dave Mansell, Deputy Director of Engineering, of the City of Kitchener Department of Development and Technical Services.

A Steering Committee will be established for the overall project study, consisting of the Project Administration staff from the City of Kitchener and representatives from the Grand River Conservation Authority, the Regional Municipality for Waterloo, City of Cambridge and affected landowners. Additional representatives from participating agencies/landowners may be included from time to time on the Steering Committee, if needed to provide specific professional input.

All funds received from cost sharing partners (agencies and landowners) will be held in a City of Kitchener study account and will be disbursed by the City in accordance with the final signed contract.

Project Information

It is anticipated that the study will be awarded and initiated in May, 2003 and completed by October, 2003.

Naylor Engineering is to be carried as the hydro geological sub-contractor.